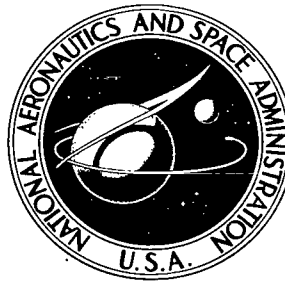


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**MOTIVE FORCES IN
THE DEVELOPMENT OF
THE EARTH AND PLANETS**

by V. V. Kesarev

"Nedra" Press, Leningrad, 1967



MOTIVE FORCES IN THE DEVELOPMENT
OF THE EARTH AND PLANETS

By V. V. Kesarev

Translation of "Dvizhushchiye sily razvitiya zemli i planet."
"Nedra" Press, Leningrad, 1967

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ABSTRACT

This book sets forth an original concept of the author concerning the nature of the Earth and the planets. The hypothetical composition of primary planetary matter is developed on a wide physical and chemical basis. Changes in planetary characteristics are connected in the closest way with the evolution of planetary matter. It is shown that the proposed chemical model of the Earth can be extended to other inner and outer planets.

The book is intended for a wide circle of readers: geologists, physicists, chemists, and for all those who are interested in modern problems of natural science.

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FROM THE EDITOR

Problems of the evolution of the Earth and the planets, to which this book is devoted, include a number of basic problems of modern science.

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Advances in the conquest of space, at the threshold of which man stands, will depend to a significant degree on the correctness of concepts concerning the composition and the state of the planets and their atmospheres.

The time is not distant when Man will set foot on the lunar surface. Already the first satellites with instruments on board have made soft landings on the Moon. Though it has become clear that the Moon is not covered with a thick layer of cosmic dust, on Earth heated arguments concerning the origin of those numerous lunar craters which Man noticed even at the dawn of his scientific and cultural development are still continuing. Such questions as to whether Mars and Venus are inhabited, the physical conditions and composition of the matter of distant planets of the solar system, how petroleum originated and how life began on Earth are illuminated in this unique and original work by V. V. Kesarev.

However paradoxical it may seem, Man evidently explained the nature of craters on the Moon significantly earlier than for example, the origin of petroleum on Earth. The majority of geologists, especially geologist-petroleum specialists, consider petroleum a product of organic origin. Some geologists, primarily cosmogonists, and also the author of this book, do not express the slightest doubt that petroleum is an inorganic substrate of matter indigenous even to those planets whose habitation is ruled out.

These are entirely opposite points of view on the origin of petroleum, while the effectiveness of applied methods for searching for valuable mineral raw material such as petroleum and gas depends on the solution to this problem.

The formation of the Earth's hydrosphere and atmosphere, stages in the evolution of the planets and an evaluation of their habitation, and many other problems are illuminated by V. V. Kesarev in this work offered for the reader's attention. It is unusual that the author presents not a compilation of opinions on all these problems, but expresses his original point of view on the causes of

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evolution of the Earth and planets, organically connecting all processes noted on it into a unified system of causes and effects. The basis of the evolution of Earth and the planets, in the opinion of V.V. Kesarev, consists of a chemical evolution of the primary planetary matter. It is mainly the chemical processes which determine the internal activity of the planets, while the energy portion of radioactive decomposition processes are considerably inferior to them.

The wide range of the most varied problems of evolution of planets (from their formation, differentiation of matter, appearance on them of life, to their destruction, disintegration, and transformation into cosmic dust) creates a clear and orderly picture of the evolution of planets and, primarily, of the Earth itself. But it is natural, with such a wide range of phenomena and with the existing debate of our concepts on various questions, that not all the positions and calculations expressed and set forth by V. V. Kesarev are indisputable.

Thus, for example, the calculation of reserves of petroleum and gas on the Earth is too optimistic; the explanation of flares on the surface of Mars as bright spots from water fountains arising with the activity of underwater volcanoes is not sufficiently convincing; and the remaining period of existence of Jupiter (300 million years) and the Sun (less than this period) in the planetary system is improbably small, etc. But all this in no way deprecates the importance of the main concept of the author on the role of chemical energy as the foundation of the evolution of planets. It is a very productive idea, the further development of which will permit an explanation of very many problems that are not clear in the field of the natural sciences.

V. P. Yakutseni

PREFACE

The modern state of science concerning the nature of the Earth /5 is characterized by the study of phenomena arising as a result of deep processes in the Earth. Since the distance between cause and effect is very great, favorable conditions for the appearance of the most contradictory explanations of observed phenomena are created. It is not accidental in the natural sciences (cosmogony, geology, biology, etc.) that an abundance of hypotheses is observed.

In this work an attempt is made to approach the problem concerning the nature of the Earth from the direction of explaining the primary planetary matter and assuming the planets to be *carriers of the properties of their matter*. The attempt at such an investigation of the nature of the Earth has shown that with a change in the properties of the planetary matter the properties and parameters of the planet itself change. In addition, in examining the nature of the Earth, it is impossible not to touch upon problems of physics, chemistry, geology, biology, and cosmogony in their close interrelationship. Here the boundaries separating these sciences are hopelessly lost. This is completely natural since we must expect a significant fusion of the natural sciences at the source in which they all originate. There is no cause to regret this loss of boundaries between the sciences, since the solution to problems often becomes possible precisely in contiguous fields - at the junction between sciences. Actually, there are no boundaries between the natural sciences; any that may exist have been invented by us.

If the new concept about the Earth set forth here does not expand the number of existing hypotheses but, on the contrary, narrows down the circle by consolidating views or even disposing of some of them, the task imposed upon this new concept can then be considered fulfilled.

INTRODUCTION

In his time O. Yu. Shmidt (1949), regarding an evaluation of the existing position in the field of cosmogony, expressed the following considerations: "In final analysis everything reduces to the cause of causes, i.e., the problem of the origin of the Earth. However, it is impossible not to acknowledge the modern position as a sad one..." The abundance of hypotheses and attempts to create a theory ultimately produces a sad impression. Acknowledgement of the fact that science here is in a state of crisis has recently been expressed by scientists of the capitalist countries. Thus, last year Jeffreys, a widely known geophysicist, published a survey of the latest West European and American hypotheses and concluded with the fact that he could not accept any of the new theories. He, by the way, renounced his own former theory, acknowledging it as untenable. V. G. Fesenkoy considers that "at the present time, in general, it is impossible to hope for the creation of an unambiguous theory for the origin of the Earth." /6

Since the time when such a characterization concerning the state of cosmogony was given, many years have passed. During this time cosmogony has been enriched with outstanding discoveries and numerous studies. However, we must admit that in the realm of constructing a theory for the origin of the Earth, no noticeable improvements have been revealed, although the number of hypotheses has increased. Natural phenomena are somewhat more complicated than contemporary hypotheses would have us believe.

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EVOLUTION OF MATTER - EVOLUTION OF A PLANET

The evolution of a planet must be closely connected with the evolution of its matter. Disregarding the natural planetary matter and its evolution would lead to the assumption that planets can be formed from any dust and to the assumption that the initial planetary matter could have been any mechanical mixture of solid, liquid and gaseous compounds provided that this mixture satisfied some kind of composition of chemical elements, whereas it is quite obvious that planetary matter must satisfy not only a given composition of chemical elements, but a given chemical structure. Only in the event of specific and successive chemical transformations can the matter of a planet serve as a motive force in its development. /7*

If for the primary planetary matter, let us say, a mixture of hydrogen or helium gases is sufficient, then diffusion into outer space will be a basic property of such planetary matter. With such a property for the planetary matter the planet created from it cannot display either internal activity or volcanic activity. It will soon evaporate and disappear.

Hydrogen and helium on a planet are generated as products of reactions occurring on it. In proportion to the formation of these gases they are raised to the surface of the planet where they accumulate in the atmosphere or disappear into space. However great the temptation has been to accept gases available for observation on a given planet as the primary planetary matter, it is useful to bear in mind that even under conditions of the Earth it is impossible to observe such matter and study it directly.

Since the key to understanding the nature of a planet lies in the primary planetary matter it is important to know its elementary composition and chemical structure. We must assume that the primary planetary matter was created in outer space long before formation of the planet. The elementary and isotopic composition of the matter and the chemical structure of the compounds must be in the most direct dependence on conditions in outer space. /8

* Numbers in the margin indicate pagination in the foreign text.

It is known that a significant part of the matter in the Universe is distributed in outer space in the form of gas and dust. The dust content is estimated to be 1-2%. In the composition of cosmic gas, hydrogen occupies the first place (90%), helium the second, and carbon, nitrogen and oxygen occupy the third place [Mel'nikov, 1957]. Also, it is known that cosmic dust consists of particles which scatter light and particles which absorb light. It is assumed that some dust particles are free metals, while others are metal oxides.

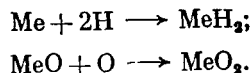
The fact that cosmic matter is found in a dispersed state (in the form of gas or dust) has deep significance from the chemical view point. This means that if the gases react with the dust we should expect a complete reaction. In the reaction of atoms, ions and hydrides, of carbon - carbides, and of nitrogen - nitrides. With the reaction of oxygen and metal oxides we can possibly assume the formation of metal peroxides.

The probability of the formation of such products results from the fact that gases in outer space remain not in the form of molecules but in the form of atoms, ions and nuclei of cosmic radiation, which permeate space. The existence of hydrides such as CH and NaH in outer space is not accidental and has been confirmed by observation [Vernadskiy, 1965].

Assuming in outer space the appearance of solid two-component compounds, the author is far from accepting the existence in space of such vaporous and gaseous materials as water, ammonia, methane, hydrocarbon, hydrogen sulfide, etc. Even under conditions of the upper layers of the Earth's atmosphere if such compounds cease to exist and disintegrate into atoms and ions, then this all the more characteristic of the conditions of outer space where atoms and ions are the usual form in which gas exists. We can assume that the conversion of cosmic gases into planetary gases is accomplished by the formation of solid hydrides, nitrides, carbides and metal peroxides with their subsequent hydrolysis. On the contrary, the conversion of planetary gases into cosmic gases is accomplished by the dissociation of molecules into atoms and ions. /9

Cosmic gases are not the same as planetary gases. Therefore, the assumption that planets are possibly created from cosmic gases consisting of methane, ammonia, water vapors, etc., which are then emitted from the depths of the planet as planetary gases, produces a number of problems. In the first place, the existence in outer space of gases in the form of molecules is assumed. In the second place, the formation of planets as a result of gases is assumed. It is not very probable, with the condensation of cosmic dust, that the small bodies created at first would be maintained by the attraction of a gas. Finally, in the third place, a difference between cosmic gases and planetary gases is assumed.

The chemical reaction of matter in outer space must be analyzed as one of the stages in the evolution of matter in the Universe. The significance of this stage consists of imparting a chemical potential to the matter. One part of the protoplanetary matter is reduced to hydrides; the other, on the contrary, is oxidized to peroxides:



Cosmic dust particles, on whose surface chemical, photochemical, radiochemical and radiation chemical processes have occurred for some time, even in their own state contain micro and macro amounts of those elements, their isotopes and compounds, which will be represented later in the young incipient planet.

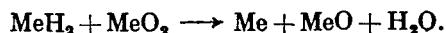
B. A. Krat [1961] likewise considers that the state of the Earth at the early stages of its development depended to a large degree on the nature of the cosmic processes.

The bodies of young incipient planets only carry the properties of the primary planetary matter. From the physical properties of these a unique variant results in forming the solid state of a planet, *not divided into zones and spheres*. Chemical properties of the planetary matter appear only on large planets. In order for a reaction between compounds of the planetary matter to occur, those physical conditions, which emerge only at certain depths of the planet, are required. Such characteristics are quite noteworthy. If special conditions were not required for a reaction of compounds of the primary planetary matter, then they would begin to react arbitrarily at any depth in the planet. The concept of planetary matter participating in the development of a planet involves precisely the fact that its compounds react at those depths and in those ratios which are determined by the physical conditions in the interior of the planet.

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The beginning of chemical processes in the interior of a young planet signifies the *beginning of internal activity in the planet*.

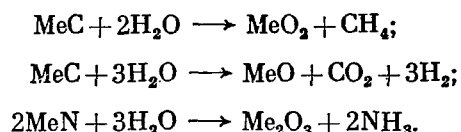
Reactions of compounds of planetary matter, such as metal hydrides and metal peroxides, lead to the occurrence of reduction-oxidation processes based on the scheme



Under conditions of outer space, if a chemical potential has been imparted to the matter, then under the conditions existing at certain depths of the planet, the matter would seem to be discharging and reducing its potential. As a result, metals and metal oxides again appear plus a new product, i.e., water. Therefore, the source of water on a planet is located not outside it, but in-

side the planet, and not in the form of a finished product, but in the form of solids, accumulating hydrogen and oxygen. On the basis of its origin, water appears to be a mineral product.

The creation of deep water in the interior of a planet and its contact with other compounds of the primary planetary matter (carbides, nitrides, etc.) leads to the creation of hydrolytic processes:



The occurrence of deep hydrolytic processes in the interior of a planet leads to the formation of new materials of mineral origin: ammonia, methane, carbon dioxide, and hydrogen. In proportion to the occurrence of deep chemical reactions, there occurs an accumulation of products of these reactions. A planet becomes a carrier not only of the primary planetary matter, but a carrier of newly forming matter. This shows up immediately on the planet itself. A planet changes its physical characteristics and loses its former uniformity. Zones and spheres are formed in it: the incipient metals form the core; the metal oxides form the mantle and crust; water forms the hydrosphere; and methane, ammonia and carbon dioxide form the atmosphere. /11

Thus, all the zones and spheres of a planet are successively produced by the planet itself as a result of its internal activity. This is a fundamental property of a planet. In light of this property of a planet, there is not the least necessity for assuming the formation of planetary spheres as the result of cosmic bodies falling randomly on its surface, especially since cosmic bodies falling on a planet from interplanetary space can not change anything, either qualitatively or quantitatively.

At the present time our planet Earth is at the stage of its development where some part of its primary planetary matter has undergone chemical change. The modern Earth carries properties of the primary matter and of other matter, i.e., the products of decomposition. The products of the deep processes were differentiated and gave rise to planetary zones and spheres.

On the basis of the dimensions of the zones and spheres of the incipient Earth, it is possible to calculate the mass of the primary planetary matter being expended and the mass of the remaining planetary matter. If we assume that the radius of the core of the Earth is 3500 km, then the matter included in this volume can be assumed as metals created from metal hydrides. The matter included in the outer zone which includes the mantle and

crust can be assumed as metal oxides created during decomposition of the primary planetary matter. An intermediate zone situated at a depth of 1000 - 2900 km remains as a part of the initial planetary matter. Because of this matter, the Earth will develop its own internal activity in the future.

D. B. Maykeluan [1949], on the basis of seismic data, concludes that a three-zone structure exists for the Earth. Boundaries of the zones are revealed quite clearly at depths of 1000 and 2900 km. In this connection B. Gutenberg [1949] notes the following: "A certain /12 sharply defined division occurs at a depth of around 1000 km."

In first approximation, a model of the Earth can be shown in the form of Table 1.

TABLE 1

Core and Mantles	Depth, km	Composition
Outer	0-1000	Oxides of Metals
Intermediate	1000-2900	Primary Planetary Matter
Core	2900-6370	Metals

A precise determination of the mass of the core and the mantles can be carried out on the basis of a reaction diagram of the decomposition of the primary planetary matter.

However, the possibility of approximately calculating the mass of the core and the mantles of the Earth on the basis of physical characteristics is not excluded. This, for example, on the basis of data concerning the depth of their boundaries, the mass ratios given in Table 2 are obtained.

TABLE 2

Core and Mantles	Depth, km	Volume, 10^{27} cm^3	Mass		Density, g/cm^2	Mass Ratio
			10^{27} g	%		
Outer	0-1000	0.473	1.613	27	3.4	1
Intermediate	1000-2900	0.436	2.270	38	5.2	1.4
Core	2900-6370	0.179	2.091	35	11.7	1.3
Total	-	1.083	5.974	100	5.516 (avg)	-

The values given above in the calculation for the overall mass of the Earth and for its mean density represent recent data [Kozlovskaya, 1963].

Let us compare the mass ratios obtained for the mantles of the Earth and the ratios resulting from the model of the Earth "a" from Gutenberg - Bullen (Table 3).

In this model of the Earth, mantles *A*, *B*, and *C* represent the outer mantle of the model of the Earth, given by us above, and mantle *D* represents its intermediate mantle. The discrepancy between the models given results from different estimations of the mass of

/13

TABLE 3

Mantles	Depth Interval, km	Density Interval, g/cm ³	Share of Earth's Volume, %	Mass, 10 ²⁵ g	Share of Total Mass, %
Crust <i>A</i>	0-33	2.7-3.0	1.55	5	0.8
Mantle <i>B</i>	33-400	3.3-3.6	16.67	62	10.4
Mantle <i>C</i>	400-1000	3.6-4.6	21.31	98	16.4
" <i>D</i>	1000-2900	4.6-5.6	44.28	248	41.0
Core <i>E</i>	2900-5000	9.4-11.5	15.16	—	—
" <i>F</i>	5000-5100	11.5-12	0.28	188	31.5
" <i>G</i>	5100-6371	12.0-12.3	0.76	—	—

the core. In our calculation the ratio of the mass of the outer mantle to the mass of the core amounts to 1:1.3, whereas according to Gutenberg - Bullen, it is equal to 1:1.1. It is worth noting that according to the Gutenberg - Bullen model the mass of the crust is too high, while the mass of the core is too low in comparison with the values accepted for these masses at the present time.

CHEMICAL COMPOSITION OF THE PRIMARY PLANETARY MATTER

One possible way to establish the composition of the initial planetary matter is to establish its final products on the basis of composition. Thus, for example, we can assume that the volcanic rocks and the matter or iron meteorites which reflect the composition of the planetary core are products of the parent planetary matter. In Table 4 the mean composition of volcanic rocks [Clark, 1924] and iron meteorites [Krinov, 1948] are given with their ratio 1:1.3 (Table 2). /14

TABLE 4

Metals and Oxides	Composition, wt. %		Mean Content, wt. %
	Volcanic Rocks	Iron Meteorites	
Fe	—	90.67	51.25
Ni	—	8.50	4.83
Co	—	0.59	0.33
SiO ₂	59.1	—	25.70
Al ₂ O ₃	15.3	—	6.65
Fe ₂ O ₃	3.1	—	1.35
FeO	3.8	—	1.65
MgO	3.5	—	1.52
CaO	5.1	—	2.22
Na ₂ O	3.8	—	1.65
K ₂ O	3.1	—	1.35
H ₂ O	1.2	—	0.52
TiO ₂	1.1	—	0.48
Other	0.9	0.24	0.52
Total	100.0	100.00	100.02

In the above calculation the mean content of iron in volcanic rocks and iron meteorites amounts to 51.25%. This figure closely approaches the iron content in such meteorites as iron - stony meteorites and pallasites. This circumstance caused the author to believe that perhaps the matter of iron - stony meteorites is similar to the initial planetary matter. In this respect it makes sense to derive the mean composition of iron - stony meteorites - pallasites and mesosiderites. This calculation is given in Table 5; compositions of meteorites are given in the books of Ye. L. Krinov [1948] and B. Meyson [1965]. /15

In the above calculation, the iron content, which must not have deviated from the number obtained in averaging the compositions of volcanic rocks and iron meteorites in Table 4, served as a guide line for choosing the ratio of meteorites.

TABLE 5

Metals and Compounds	Content, wt. %		Average for a 1:1 Ratio
	Pallasites	Mesosiderites	
Fe	55.33	43.49	49.41
Ni	5.43	3.94	4.68
Co	0.3	0.38	0.34
SiO ₂	17.27	24.13	20.69
MgO	20.55	7.31	13.92
Al ₂ O ₃	—	5.48	2.74
Fe ₂ O ₃	—	2.08	1.04
FeO	—	2.72	1.36
FeS	—	3.04	1.52
Fe ₂ P	—	1.42	0.71
Cr ₂ O ₃	—	0.39	0.19
MnO	—	0.08	0.04
CaO	—	4.46	2.23
Na ₂ O	—	0.20	0.10
Other	1.22	0.88	1.05
Total	100.00	100.00	100.00

A comparison of the mean composition of iron - stony meteorites with the mean composition of volcanic rocks and iron meteorites shows that iron - stony meteorites are poor in alkali metals. We must assume that a product of a formation earlier than the material of iron - stony meteorites had combined fusible and refractory components. The matter of iron - stony meteorites could appear after evaporation or melting of alkali metal silicates. In order to establish the composition of a material before melting silicates of alkali metals from it, it is necessary, in our opinion, to derive the mean composition on the basis of four compositions: compositions of volcanic rocks, iron meteorites, and two groups of iron - stony meteorites. In Table 6, the calculation is given for the mean composition on the basis of the above four compositions, obtained in Tables 4 and 5. /16

In this calculation the mean composition obtained on the basis of the other two compounds probably has characteristics which are too low for potassium oxide, titanium oxide and water. This is explained by the fact that in the composition of iron - stony meteorites the content of the indicated compounds is obviously included in the number of "others". It is not accidental that in this column the high figure is 1.05. In order to correct this situation, the number 1.05 must be divided into 0.1 for potassium oxide, 0.2 for titanium oxide, 0.25 for water and the remaining part, 0.5, for "others". In this case, we have 0.73 in the mean composition /17

TABLE 6

Metals and Compounds	Mean Composition, wt. %		Average of 1 and 2 with a 1:1 Ratio
	1. Volcanic Rocks and Iron Meteorites	2. Pallasites and Mesosider- ites	
Fe	51.25	49.41	50.33
Ni	4.83	4.68	4.75
Co	0.33	0.34	0.33
SiO ₂	25.70	20.69	23.20
Al ₂ O ₃	6.65	2.74	4.69
Fe ₂ O ₃	1.35	1.04	1.20
FeO	1.65	1.36	1.50
MgO	1.52	13.92	7.72
CaO	2.22	2.23	2.22
Na ₂ O	1.65	0.10	0.87
K ₂ O	1.35	—	0.67
H ₂ O	0.52	—	0.26
TiO ₂	0.48	—	0.24
FeS	—	1.52	0.76
Fe ₂ P	—	0.71	0.35
Cr ₂ O ₃	—	0.19	0.10
MnO	—	0.04	0.02
Other	0.52	1.05	0.78
Total	100.02	100.02	100.00

column of Table 6 for potassium oxide, 0.39 for water, 0.34 for titanium oxide, and 0.51 for the "others".

The mean composition obtained on the basis of volcanic rocks, iron and iron - stony meteorites still is not the primary planetary matter, because it does not contain those light elements and their volatile compounds that have not been retained either in volcanic rocks or in meteorites, whereas all light elements must occur in the primary planetary matter.

An examination of the chemical properties of metals included in the mean composition obtained on the basis of volcanic rocks, iron and iron - stony meteorites permits the assumption that in the primary planetary matter, alkali and alkali-earth metals performed the role of peroxide compounds; metals of the iron family (iron, nickel and cobalt) performed the role of hydrides. In addition, iron could participate in the primary planetary matter in the form of carbides, phosphides and sulfides; titanium in the form of carbides and nitrides; chromium in the form of nitride; and manganese in the form of carbide.

Oxides of alkali and alkali-earth metals included in the composition of iron - stony meteorites could be formed from the respective peroxides. This affects sodium, potassium and calcium. These metals and their oxides in an oxygen stream form peroxide compounds of various composition. The most stable peroxide for sodium is Na₂O₂, for potassium KO₂, and for calcium CaO₂. Several known properties of the above peroxides are given in Table 7.

TABLE 7

Metal Peroxide	Heat of Formation, kCal/mole	Density, g/cm ³	T _{melt} , °C
Na ₂ O ₂	124	2.805	460
KO ₂	135	2.136	380
CaO ₂	157.4	—	—

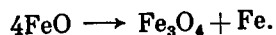
We must assume that under conditions of high pressure, the fusibility and heat resistance of peroxides will be significantly higher.

Oxides of iron and manganese, represented in the composition /18 of iron - stony meteorites, could be formed from iron and manganese carbides during their hydrolysis. For iron, carbides of Fe₂C and Fe₃C (cementite) composition are known. For manganese, the carbide Mn₃C is known. In Table 8 some of their properties are given.

TABLE 8

Metal Carbide	Heat of Formation, kCal/mole	Density, g/cm ³	T _{melt} , °C
Fe ₃ C	-3.5	7.4	1837
Mn ₃ C	+23.0	6.89	1520

In the composition of iron - stony meteorites, iron is represented in two states: bivalent and trivalent. We must assume that the hydrolysis of cementite in the interior of the Earth occurs only with the formation of bivalent iron which, during cooling to a temperature below 600° C, partially converts to the trivalent state on the basis of the reaction



Iron phosphide and sulfide, found in the composition of iron and iron - stony meteorites, probably existed in the primary planetary matter precisely in this form and still have not been able to undergo chemical change. Several known characteristics for them are given in Table 9.

Of the other metals included in the composition of iron - stony meteorites, titanium and chromium are of interest from the point of view of their being in the primary planetary matter in the form of carbides and nitrides. Compounds of titanium with carbon

TABLE 9

Iron Compounds	Density, g/cm ³	$T_{\text{melt}}, ^\circ\text{C}$
FeP	6.07	
Fe ₃ P	6.56	1290
FeS	4.84	1193
FeS ₂	5.0	1171

and nitrogen analogous to these/19 materials have been discovered in blast furnace slags in the form of crystals of the compound Ti_5CN_4 . We must assume that this is a binary compound $\text{TiC} \cdot 4\text{TiN}$ and is created from the reaction of titanium with carbon and nitrogen. The compound CrN of chromium and nitrogen is known. Several characteristics of these compounds are presented in Table 10.

TABLE 10

Compounds	Heat of Formation, kCal/mole	Density, g/cm ³	$T_{\text{melt}}, ^\circ\text{C}$	$T_{\text{boil}}, ^\circ\text{C}$
TiC	110	4.2-4.7	3140	-
TiN	80	4.7	2950	-
CrN	-	7.16	1890	2570

Metals of the iron family included in the composition of iron-stony meteorites could be formed from the respective hydrides. It is known that these metals absorb significant amounts of hydrogen, especially in a finely crushed state and at elevated temperatures. Indirectly it is possible to obtain solid hydrides of the structure EH_x , where x has a value from 1 to 6 [Nekrasov, 1954]. According to T. Weihselfelder [1926] metal hydrides of the iron family have the formula EH_2 , while the formula FeH_6 represents iron. Transition metals do not differ in their resistance, in particular the dihydrides of cobalt, nickel and iron are endothermic compounds. Their heat of formation is equal respectively to: -14.55, -5.9 and -11.4-14.5 kCal/mole. The crystal lattice of metals during hydrogenation is expanded and therefore the density of the hydrides is significantly lowered in comparison with the density of the metal. During hydrogenation of zirconium its density is decreased by 24% [Mikheyeva, 1960].

If we assume that metal hydrides of the iron family could be formed during reaction of the metals, not with molecular hydrogen, but with hydrogen in the form of atoms, ions and hydrogen nuclei, endowed with high kinetic energy, the probability of their formation in the planetary matter is not entirely excluded. Only the problem of the composition of iron hydride remains unsolved. Let us take the minimum possible formula for all metals of the iron family EH_2 . Since hydrides of elements completing the transition series

(copper, zinc, silver, cadmium, gold and mercury) possess volatility to some degree, this being a property of compounds with a covalent bond [Mikheyev, 1960], metals of the iron family bordering on these metals form compounds with hydrogen that are almost covalent. Hence we recognize that the density of iron hydrides can not be high, and further assume it to be equal to 2.0.

In a number of other oxides, iron - stony meteorites contain significant amounts of oxides of silicon, magnesium and aluminum. On the basis of the chemical nature of these compounds it is not possible to endow metals of these oxides with any functions in the planetary matter other than those which are characteristic of them in the form of oxides.

We must assume that these compounds, which are stable in their physical and chemical ratios, enter and leave the planetary matter with no chemical change. In Table 11 several characteristics of oxides of silicon, aluminum and magnesium are presented.

TABLE 11

Oxides	Heat of Formation, kCal/mole	Density, g/cm ³	$T_{\text{melt}}, ^\circ\text{C}$	$T_{\text{boil}}, ^\circ\text{C}$
SiO ₂	203	2.65	1713	2590
Al ₂ O ₃	209	3.9	2050	2250
MgO	146	3.65	2800	3600

Now when the specific compounds, which are included in the composition of planetary matter, are designated it is possible to convert to quantitative determinations of these compounds. The mean composition given in Table 6 must be taken as the basis of the calculation. The metals of the iron family indicated in this table must be replaced by hydrides of these metals. Metal hydrides of iron, titanium, chromium and manganese must be replaced by the respective carbides and nitrides, while oxides of alkali and alkali earth metals must be replaced by the respective peroxides of these metals. As a result of such replacement the total number of compounds is increased to 102, 176%. By subsequent recalculation of the amounts of all the compounds, their total sum is reduced to 100%. The final result is given in Table 12. /21

Let us give an example of such a calculation for iron. According to Table 6, 50.33% metallic iron is given. Translating this amount of iron into a dihydride of iron, we obtain 52.18%. By converting the total number of compounds to 100% the amount of iron dihydride is decreased to 51.022%. This number is included in Table 12.

Thus, on the basis of fragments formed during decomposition of the whole, the probable composition of the *primary planetary matter* is calculated. It consists of two-component compounds: 56.16%

TABLE 12

Metals	Wt. %	Metal- loids	Wt. %	Com- pounds	Wt. %	Density, g/cm ³
Fe	49.262	H	1.76	FeH ₂	51.022	(2.9)
Ni	4.65	H	0.155	NiH ₂	4.805	—
Co	0.322	H	0.01	CoH ₂	0.332	—
Si	10.60	O	12.107	SiO ₂	22.707	2.3
Al	2.43	O	2.16	Al ₂ O ₃	4.59	2.3
Mg	4.533	O	3.023	MgO	7.556	3.6
Fe	1.964	C	0.14	Fe ₃ C	2.104	7.4
Ti	0.039	C	0.01	TiC	0.049	4.2
Mn	0.013	C	0.002	Mn ₃ C	0.015	—
Ti	0.159	N	0.046	TiN	0.205	4.2
Cr	0.07	N	0.02	CrN	0.09	7.1
Fe	0.473	S	0.27	FeS	0.743	4.8
Fe	0.26	P	0.08	Fe ₃ P	0.34	6.5
Ca	1.55	O	1.24	CaO ₂	2.79	(3.9)
Na	0.63	O	0.436	K ₂ O ₂	1.066	2.8
K	0.60	O	0.486	KO ₂	1.086	2.1
Other	0.50	—	—	—	0.50	—
	78.055	—	21.945	—	100.000	2.9

hydrides of iron, nickel and cobalt; 34.85% oxides of silicon, aluminum and magnesium; 2.17% carbides of iron, titanium and manganese; 0.3% nitrides of titanium and chromium; 4.94% peroxides of calcium, sodium and potassium; and 1.08% sulfides and phosphides of iron. The total amount of metals amounts to 78% and of non-metals, 22%. All of these compounds with the exception of compounds of alkali metals, are hard, refractory and heat resistant, with a mean density of 2.9. We found the specific gravities of the compounds (in parentheses) by comparison with other known and similar compounds. The mean density of the primary planetary material is determined mainly by the basic density of the iron hydrides. Unfortunately, in the literature, specifically for iron hydrides, there is no information about their densities. However, taking into consideration the fact that there is an overall tendency for the density of heavy metals to decrease with conversion to hydrides, and that compounds such as chlorides and fluorides of iron have a density lower than 3, the value 2.9, assumed for the density of iron hydride is probable. In the future, if the density of iron hydrides is found and is different from the value which we have assumed, it will be possible to introduce corrections into the calculation.

In the chemical aspect, compounds of the primary planetary matter can be characterized as compounds which, under proper conditions, may undergo oxidation-reduction and hydrolytic reactions.

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Of the compounds of the primary planetary matter, at the present time only oxides of silicon, aluminum, and magnesium are available for observation since in this form they enter and leave the planetary matter without chemical change. The other compounds of the planetary matter are concealed at a great depth in the intermediate zone of the Earth and only occasionally are any of them observed. Thus, for example, titanium nitride has been observed in the lava of the volcano Vesuvius. This compound, in the form of an osbornite mineral, is found in achondrite meteorites. It is widely known that compounds of the primary planetary matter (carbides, nitrides, phosphides and sulfides of metals) are found in planetary fragments, meteorites, which reflect the composition of matter deep in the planets.

THE YOUNG EARTH

There are two extreme cases of the state of a planet: first, when the planet is a carrier of only primary planetary matter and second, when the planet is a carrier of only decomposition products of primary planetary matter. Differences in the state of planets in these two extreme cases are no more or less than those which result from the physical and chemical properties of planetary matter and its decomposition products.

/23

Let us examine a variant of the state of the Earth at a time when it was young and consisted of only primary planetary matter. Prior to the beginning of the planet's internal activity its composition included the following matter: 56% metal hydrides of the iron family; 35% oxides of silicon, aluminum and magnesium; and 9% carbides, nitrides, peroxides, sulfides and phosphides of metals. With such a chemical structure a planet could have a regular geometric shape and could be uniform throughout in depth. Analogously to the Earth all the other planets of the solar system were formed from the same primary planetary matter and had neither zones nor spheres. This situation must be emphasized since it is opposed to certain existing concepts. According to these concepts the planets of the solar system were created nonuniform and nonidentical in composition; planets near the Sun were formed from dense matter and those far from the Sun mainly from gases of a protoplanetary cloud .

The essence of these concepts has been rather clearly formulated by S. V. Kozlovskaya [1953]: "In the process of evolution of a cloud there appeared a difference in the composition and quantity of dust matter at different distances from the Sun", and by E. Shatsman [1954]: "The differences in chemical composition of the planets reflect the physical and chemical conditions which existed in the initial nebula."

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It is entirely obvious that the above concepts would have the distribution of material by composition in a protoplanetary cloud being the same as the modern external state of the planets. In our opinion this can not happen. Billions of years have separated this stage in the formation of the planets from their modern state. The outer planets were not formed as they now appear. They were identical in all aspects with the exception of their masses. The Sun appeared simultaneously with the planets from this primary planetary

matter. The uniformity in composition of matter throughout the entire nebula and the distribution of matter on the basis of mass in the various zones of the nebula were determined by the evolution of the cloud. The Sun did not affect the distribution of matter in the protoplanetary cloud since it could exert its influence on the environment only when the cloud had already been condensed and large and small bodies had been formed.

The modern picture of the solar system reflects the distribution of matter in the primary nebula on the basis of mass. The basic mass of matter in the nebula was distributed in two zones, with a tendency for the formation of a double star: Sun - Jupiter. Since there were insufficient masses of protoplanetary matter in the zone where Jupiter was formed, the development of the second star ceased.

In addition, the modern picture of the solar system reflects the *nonuniform* development of various bodies in relation to mass. At the start all the planets were *identical in their structure*, whereas by the present time they have reached different degrees of development. Thus it would seem that the planets are nonuniform in composition. However, if we introduce a correction into the characteristics of the planets for their extended atmospheres the concept of a nonuniformity in composition of the planets vanishes.

As a result of the physical and chemical properties of the primary planetary matter it is possible to derive certain characteristics for its carrier - the young Earth. The formation in the Earth of a core with a mass of 35% or $2.09 \cdot 10^{27}$ g consisting of the metals, iron, nickel and cobalt, with a specific gravity of 7.9 could occur with the decomposition of $2.16 \cdot 10^{27}$ g of dihydride of iron, cobalt, and nickel with a specific gravity of 2.9. As a result of this process the volume of the planet diminished by $0.48 \cdot 10^{27}$ cm³. If the volume of the modern Earth is equal to $1.08 \cdot 10^{27}$ cm³, then the volume of the young Earth could amount to $1.56 \cdot 10^{27}$ cm³. The total mass could also be more than the modern mass by the value of the escaped hydrogen, i.e., $0.036 \cdot 10^{27}$ g. The overall mass of the modern Earth is estimated at $5.974 \cdot 10^{27}$ g, therefore the total mass of the young Earth was $6.01 \cdot 10^{27}$ g. By knowing the volume and mass of the young Earth it is possible to calculate some of its other characteristics. Such a calculation is given in Table 13. /25

According to this calculation, the mean density obtained for the young Earth is somewhat too high. The mean density of the planets increases noticeably in connection with the growth of the core. Since there was still no core in the young Earth, its mean density could not be higher than that of the modern Moon - 3.34.

There is still another method for defining the mean density of the young Earth. The modern density of the Earth (5.52) became possible due to a 35% core formation. Later it will be shown that with the growth of the Earth's center from 35 to 54.5% the mean density grows by 1.3. People ask, by how much the density of the

Earth increases with a growth in the core from 0 to 35%?

TABLE 13

Parameters	Calculation Data for the Young Earth
Total Mass	$6.01 \cdot 10^{27}$ g
Mass of the Core	0.0
Mass of Hydrogen	$0.12 \cdot 10^{27}$ g
Total Volume	$1.56 \cdot 10^{27}$ cm ³
Mean Density	3.8 g/cm ³
Radius	7200 km

The answer is 2.3. This means that the mean density of the Earth prior to formation of its core was 3.2.

There are two characteristic variants for the young Earth:
variant 1 - a mean density of 3.8, a total volume of $1.56 \cdot 10^{27}$ cm³,
a radius of 7,200 km, a surface area of 651 million km², and vari-
ant 2 - a mean density of 3.2, a total volume of $1.88 \cdot 10^{27}$ cm³, a
radius of 7650 km, and a surface area of 735 million km².

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An evaluation of the linear contraction of the Earth's crust, or of the contraction of the Earth's radius involved in the formation of elevations and depressions will be the determining factor for selection of the variant. It has been calculated, for example, that as a result of the formation of the Alps, the linear contraction of the surface of the Earth's crust amounted to 120 km while the contraction of the Earth's radius was 19 km. We can also predict the contraction of the Earth's radius by the formation of oceanic depressions. If we bear in mind that the radius of the young Earth was 7200 km, while that of the modern Earth is 6370 km, the total contraction of the radius then is 830 km. Such a contraction of the radius of the Earth became possible as a result of the formation of 22 elevations analogous to the Alps and as many oceanic depressions.

The possibility that the ancient Earth had the same shape as it now has is not excluded. It is of interest to cite several considerations from a book by M. M. Charygin [1963]: "Many consider that in very ancient times the Earth revolved around its axis significantly faster than in modern times. This speed diminished with the passage of time. The length of days gradually increased from 5½ to 24 hours. It is natural that the flattening (compression) of the Earth diminished with time. With the lengthening of days from 5½ hours the polar radius reached about 6000 km, the equatorial radius about 8100 km. In modern times the polar radius is 6356 km, and the equatorial radius 6378 km. In other words, the Earth was formerly a strongly flattened ellipsoid of rotation. Subsequently, the Earth began more and more to approach the shape of a sphere."

The above considerations concerning the change of the Earth's shape with the preservation of its volume are cited as an explanation for the tectogenesis of the Earth's crust. In our opinion the logic of placing the problem in such a plane is superfluous: the entire structure of the Earth, including the structure of the Earth's crust, testifies to the fact that the young Earth had an ellipsoidal shape and a significantly larger volume than does the modern Earth.

Not only the physical nature of the young planet, but the chemical nature as well, is a result of the properties of the primary planetary matter. In the deep zones of the planet, physical conditions with respect to temperature and pressure were created in which a reaction between components of the primary planetary matter became possible. The beginning of the internal activity of the young planet occurred with the onset of deep-seated chemical reactions. The deep-seated matter, as though it were discharging itself by individual parts, sometimes shakes the planet and always warms it, constantly emitting gaseous, liquid and solid reaction products to the planet's surface. In light of this, the inert part of the composition of primary planetary matter is very important. Oxides of silicon, aluminum and magnesium, being 1/3 of the total mass of primary planetary matter, perform the task of a reflux condensor. If the reactive components of the primary planetary matter were not diluted by the reflux components, the young Earth would be a genuine "powder magazine." The high chemical potential of primary planetary matter characterizes the young planet, the carrier of this matter, as a *thermodynamically unstable system*. There is reason to assume that, especially for young planets, the possibility of their destruction as a result of high internal activity is not excluded.

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THE MODERN EARTH

The Earth, during the time of its internal activity, underwent no sharp changes in its elementary composition. In its composition the hydrogen content could change as a result of dissipation. However, during this time strong changes occurred in the chemical structure of the planetary matter. The modern Earth became a carrier not only of the primary planetary matter but of its decomposition products as well. In proportion to the primary planetary matter expended, its ratio to the decomposition products continually changes. This means that the overall characteristics of the planet continually change. The characteristics of the modern Earth essentially reflect the ratio of initial planetary matter to its decomposition products. Let us calculate this ratio for the modern Earth. Such a calculation of primary planetary matter and its decomposition products (wt%) in proportion to the total mass of the Earth is given in Table 14.

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Let us illustrate the calculation technique with iron hydride. According to Table 12 the total amount of iron dihydride amounts to 51.022%. From this amount, 32.79% decomposed with the formation of 31.66% metallic iron and its migration to the core. This amount of iron was sufficient, with other metals, to form the Earth's core with a mass of 35%. In addition to the iron, with the decomposition of iron hydride, 1.13% hydrogen was formed. This, in its elementary form and in the form of water, entered the outer crust of the Earth. From the initial amount of iron dihydride, 18.23% remained unexpended. This part remains as before in the intermediate stratum of the Earth. On the basis of Table 14, the total amount of iron dihydride is 51.022% and is distributed in the following way: in the intermediate crust, 18.23% in the form of the initial iron dihydride; in the core, 31.66% in the form of iron; and in the outer crust, 1.13% in the form of hydrogen.

In the above calculation for the distribution of matter on Earth by mantles, a core mass of 35% was used as the reference number. All the remaining figures in the calculation flowed logically from the composition of planetary matter. As a result we found that the mass of the outer mantle, chemically equivalent to the mass of the core, is equal to 29%. The ratio between the mass of the outer mantle and that of the core is 1:1.2.

According to the calculation given in Table 2, the mass ratio

of the outer mantle and the core was found to equal 1:1.3. Here this ratio was changed as a result of the mass of the outer mantle changing due to the light elements and their compounds which could not be taken into account earlier.

TABLE 14

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Metals	Wt. %	Metal- loids	Wt. %	Com- pounds	Wt. %	Core and Mantles
Fe	17.60 31.66	H	0.63	FeH ₂	18.23 31.66	Intermed. Core
Ni	1.66 2.99	H	1.13 0.055	NiH ₂	1.13 1.715	Outer* Intermed.
Co	0.115 0.207	H	0.10 0.004	CoH ₂	0.10 0.119	Core Intermed.
Si	3.80 6.80	H	0.007		0.007	Core
Al	0.87 1.56	O	4.34 7.77	SiO ₂	8.14 14.57	Outer Intermed.
Mg	1.62 2.91	O	0.77 1.39	Al ₂ O ₃	1.64 2.95	Outer Intermed.
Fe	0.70 1.26	O	1.08 1.94	MgO	2.70 4.85	Outer Intermed.
Ti	0.014 0.025	C	0.05 0.09	Fe ₃ C	0.75 1.35	Intermed. Outer
Mn	0.005 0.008	C	0.003 0.006	TiC	0.017 0.031	Intermed. Outer
Ti	0.057 0.102	C	0.0004 0.0006	Mn ₃ C	0.0054 0.0086	Intermed. Outer
Cr	0.026 0.044	N	0.016 0.03	TiN	0.073 0.132	Intermed. Outer
Fe	0.17 0.30	N	0.007 0.012	CrN	0.033 0.056	Intermed. Outer
Fe	0.09 0.17	S	0.10 0.17	FeS	0.28 0.47	Intermed. Outer
Ca	0.55 1.00	P	0.024 0.046	Fe ₂ P	0.114 0.206	Intermed. Outer
Na	0.226 0.404	O	0.44 0.40	CaO ₂	0.99 1.40	Intermed. Outer
K	0.21 0.39	O	0.40 0.14	CaO	1.40 0.40	Outer Outer
Other	0.18 0.20 0.12	O	0.157 0.14 0.14	Na ₂ O ₂	0.383 0.544 0.14	Intermed. Outer Outer
		O	0.17 0.08 0.24	KO ₂	0.38 0.47 0.24	Intermed. Outer Outer
		—	—	K ₂ O	0.47	Outer
		—	—	O	0.24	Outer
		—	—	—	0.18	Intermed.
		—	—	—	0.20	Core
		—	—	—	0.12	Outer
					100.00	

* This includes the upper mantle and crust.

A 36% mass of matter enters part of the intermediate mantle. If we bear in mind that the matter in the intermediate mantle is primary planetary matter, while matter in the outer mantle and core are its decomposition products, the ratio of their masses then amounts to 1:18. With the further development of the Earth, this ratio will constantly change with the expenditure of primary matter and the growth of its decomposition products. When primary matter is completely expended, the intermediate mantle will disappear, and as a result the outer mantle and the core will increase, respectively, to 45.5 and 54.5%. Their ratio, as before, will be 1:1.2.

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A comparison of data from calculations which we made on the elementary composition of the modern Earth (on the basis of the composition of primary planetary matters) with the data from calculations by other authors (based on other assumptions) is of interest.

From the comparison it is obvious that different methods of calculating the elementary composition of the Earth yield significant discrepancies, especially concerning the amounts of iron, silicon and hydrogen. It should be noted however, that the same method (based on the compositions of stony and iron meteorites) will yield no less of a discrepancy among the various authors since there is an unknown quantity - the ratio of stony to iron meteorites. A. P. Vinogradov, on the basis of calculations, assumed a ratio of these meteorites in which the average amount of iron is 36.9%. Probably such a ratio of stony to iron meteorites was chosen in order to reconcile the amount of iron in the Earth with the existence of its metal core having a mass of 35%. If, however, we bear in mind that with the development of planets their cores increase as a result of the decomposition of hydrides of iron, nickel and cobalt, it is then necessary to assume so many of these metals on the planet that they would be sufficient for the maximum growth of the core, i.e., up to 54.5% (Table 14). Here we must not forget that iron also occurs in the form of compounds in the outer mantle of a planet. Too-low calculations of iron in a planet unavoidably entail too-high indications of silicon. Since silicon is found in a planet in the form of silicates and dioxides, this involves an increase in the hydrogen content in the composition of the planet. Therefore, the main problem concerning the composition of a planet involves the iron content in it.

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As the basis of his calculations on the composition of the Earth, V. Yu. Levin assumes such a ratio of iron to stony meteorites in which the average content of iron in the Earth is 25%. It seems to us that such a ratio of iron and stony meteorites is not feasible. With only 25% of the iron in the Earth in the form of a metal, the mean density of the Earth would not be equal to 5.5, but rather to 5.0. The metal core of Venus is 31%; its mean density is 5.2. If we still bear in mind that part of the iron on Earth is found in the form of compounds, the mean density of which is significantly lower than metallic iron, the mean density of the

Earth would then be inadmissibly low. However, we must note that any ratio of iron to stony meteorites can not yield a correct reflection of the elementary composition of the planet. If the iron

TABLE 15

Elements	Composition of the Earth, wt. %	
	V. V. Kesarev	A. P. Vinogradov
Fe	51.96	36.9
Ni	4.6	2.9
Si	10.6	14.9
Al	2.4	3.0
Mg	4.5	6.7
Ca	1.6	2.9
Na	0.6	0.9
K	0.6	0.29
O	19.4	29.3
C	0.15	0.6
N	0.066	
S	0.27	0.7
P	0.08	0.15
H	1.92	
Other	0.50	0.76

meteorites reflect the composition of the core, while the stony meteorites reflect the composition of the outer zone of the planet, then what fragments reflect the composition of matter in the intermediate zone of the planet? Perhaps comets are such fragments. The properties of comets actually correspond well to the physical and chemical characteristics of primary planetary matter. They could be indications of the composition of matter in the intermediate zone of the planet were they not imperceptible. In contrast to meteorites they completely evaporate in the fall to Earth.

The position that the elementary composition of the Earth can be determined by a meteorite method can not be a proper one, not only because an arbitrary ratio of iron and stony meteorites is assumed, but also because all the fragments of the planets are not taken into account.

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THE EARTH'S MANTLE

The structure of the Earth (with the formation of a core, mantle, and crust), which has been created, is the result of internal activity in the planet. In order to formulate a concept of this internal activity and to explain its relationship to the structure of the planet, we must look at the nature of the deep-seated chemical processes and their effects. /33

Let us look at these processes in the following order: (1) time and location of the deep-seated chemical reactions; (2) rate; (3) direction; (4) energy; (5) properties of the reaction products (with respect to volume, pressure, temperature, electromagnetic properties and differentiation).

Time and Location of Deep-Seated Chemical Processes

We mentioned earlier that deep-seated chemical reactions and consequently, the internal activity associated with them may be created on planets with a sufficiently small mass. The chemical nature of the compounds in primary planetary matter requires that the proper temperature and pressure conditions exist for them to react. The concept of planetary matter participating in the development of a planet means specifically that its compounds must react at those depths and in those ratios which are determined by physical conditions in the interior of the planet, rather than arbitrarily at any depth.

Since deep-seated chemical processes are associated with the reaction of components in primary matter it is natural to assume that these processes in the modern Earth occur in the mantle where the primary planetary matter is found. This mantle may be either the intermediate mantle or the lower mantle located at a depth of 1000 - 2900 km. Seismic investigations give a basis for assuming that precisely at the boundaries of this mantle, the planetary matter is found to be in transitional stages. The seismic velocity at the upper boundary of the intermediate mantle remains constant and equal to 11 km/sec over a range of 100 km. At the lower boundary of this mantle the seismic velocity drops from 13.6 to 8 km/sec. The reason for such a sharp conversion of the matter from one state to another must be associated, in our viewpoint, with the chemical processes and the chemical change in the matter. /34

If we examine these and other circumstances in light of the

chemical properties of the primary planetary matter found in the lower mantle, we may assume the upper and lower boundaries of the lower mantle to be *reaction strata* of the Earth.

In the first reaction stratum, located at the lower boundary of the lower mantle, from depths of 2850 to 2950 km, chemical reaction processes take place between metal hydrides of the iron family and peroxides of alkali and alkali earth metals. Following these primary processes, a secondary reaction takes place between the deep water containing metallic iron and the oxides of alkali and alkali earth metals. These processes are huge in scale, in abruptness of conversion of the matter and in the amount of energy yielded. These factors, taken in aggregate, are sufficient to explain changes in the matter at the boundary between the lower mantle and the core.

When a planet is in the process of decomposition and if it is composed primarily of decomposition products from the original planetary matter, in the form of meteorite fragments, such a composition would then correspond to iron - stony meteorites having all the light and volatile elements and their compounds in them. However, it is impossible to make any determination concerning the decomposition product since the process of forming planetary fragments is accompanied by the evaporation of volatile compounds.

The matter comprising the center zone of the first reaction stratum is nearest in its elementary composition to that of the original planetary matter. This composition is reflected in the iron-stony meteorites (mesosiderites). Unlike the primary decomposition product, the matter from which the mesosiderites were formed has already lost hydrogen and water and is significantly depleted of the /35 fusible silicates of alkali metals. The matter from the lower zone of the first reaction stratum is composed of other iron - stony meteorites, i.e., pallasites, entirely depleted alkali metals and silicon dioxides. The deeper the matter is distributed in the reaction stratum, the closer its composition will be to that of the iron meteorites and the nearer the stratum itself will be to the boundary of the metallic core.

Iron meteorites represent everything that enters the core from the first reaction zone. Stony meteorites represent everything that enters the upper mantle and the crust from the first reaction zone. With further movement of the matter upward and downward from the reaction stratum, the composition of the matter undergoes constant change. Meteorites of different composition obviously reflect matter from the various depths of decomposing planets. To establish the average composition of meteorites precisely, we must know their weight ratios. Since these data are lacking, the average composition of the entire outer mantle, i.e., the upper mantle and crust can be found from the calculations given in Table 14 under the column "outer mantle". In this table the composition of the outer mantle is expressed in wt. % of the total mass of the Earth. The results of converting this composition with respect to the mass of the outer

mantle are given in Table 16 in wt. %. Inasmuch as components of the primary planetary matter such as metal carbides, nitrides, sulfides and phosphides did not undergo hydrolysis in the first reaction stratum (they can be found in the composition of enstatitic chondrites), the composition of the outer crust prior to and after hydrolysis of the planetary matter components is given in Table 16.

It is interesting to note that the average amount of silicon dioxide in the upper mantle and crust corresponds to the amounts contained in a mixture of ultrabasic (40%) and acidic (65%) magmas.

Under the conditions existing in the upper mantle the individual matter components form compounds that are more complex than oxides during reaction. Water and silicon dioxide act as the agglutinants. Table 17 gives a sample calculation for the combining chemical bonding of water and silicon dioxide.

By comparing the obtained mean densities for the oxides and salts, formed from the oxides, we can see that the matter is condensed from 2.8 to 3.3. We can therefore compute not only the mean chemical composition of the matter for the outer stratum of the Earth but

/36

TABLE 16

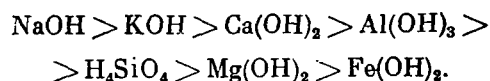
Compounds before Hydrolysis	Wt. %	Density, g/cm ³	Compounds after Hydrolysis	Wt. %	Density, g/cm ³
SiO ₂	50.0	2.3	SiO ₂	50.0	2.3
MgO	16.6	3.58	MgO	16.6	3.58
Al ₂ O ₃	10.1	3.5	Al ₂ O ₃	10.1	3.5
CaO	4.8	3.37	CaO	4.8	3.37
Na ₂ O	1.86	2.27	Na ₂ O	1.86	2.27
K ₂ O	1.6	2.32	K ₂ O	1.6	2.32
Fe ₃ C	4.6	7.4	FeO	7.58	5.45
TiC	0.1	4.2	TiO ₂	0.65	3.84
Mn ₃ C	0.03	6.9	MnO	0.036	5.4
Fe ₂ P	0.7	6.5	Cr ₂ O ₃	0.23	5.21
CrN	0.2	7.1	CH ₄	0.44	—
TiN	0.4	4.2	NH ₃	0.158	—
FeS	1.6	4.8	PH ₃	0.154	—
H ₂ O	3.0	1.0	H ₂ O	0.71	1.0
H ₂	4.0	—	H ₂	4.068	—
—	—	—	H ₂ S	0.615	—
Other	0.4	—	Others	0.4	—
	100.0	2.87		100.0	2.80

TABLE 17

Basic Oxides	Wt %	Wt. % of Water	Wt. % of Silicon Dioxide	Salts	Wt. %	Density, g/cm ³
MgO	16.6	—	25.8	MgSiO ₃	42.4	3.28
Al ₂ O ₃	10.1	—	6.0	Al ₂ O ₃ ·SiO ₂	16.1	3.23
FeO	7.58	—	6.2	FeO·SiO ₂	13.78	3.5
CaO	5.0	—	5.4	CaSiO ₃	10.4	2.9
Na ₂ O	1.8	0.5	3.5	NaHSiO ₃	5.8	—
K ₂ O	1.5	0.21	1.6	KHSiO ₃	3.31	—
Other	0.9	—	1.5		2.4	—
	43.48	0.71	50.0		94.19	3.3

its mean density under normal conditions as well.

From the viewpoint of classical chemistry it is untenable to assume that hydroxides and acid salts of silicon dioxide can be formed at high temperatures. However, studies show that metal hydroxides possess stability at high temperatures as well as volatility. S. A. Shchukarev [1965], on the basis of thermodynamic calculations, showed that the volatility of hydroxides in the presence of water vapor is characterized by the following sequence: /37



Hydroxides of alkali metals possess and accelerated rate of migration from the interior toward the surface of the Earth. To understand the large-scale process involved in the travel of certain matter upward from the reaction stratum, we must analyze the processes taking place during zone melting rather than basing our analysis on the processes involving the fracture of rocks, that can be seen in the Earth's crust, or on the processes involving the forces of gravitation.

During its upward migration, the deep-seated matter undergoes further chemical change at the upper boundary level of the intermediate stratum of the Earth. The *second reaction stratum* of the Earth is found at a level of 850 - 950 km. Here partial hydrolytic reactions of metal carbides are possible to a lesser degree than are those of metal sulfides. Chemical changes in the matter and the energy yielded by these chemical reactions are apparent in that no increase is observed in seismic velocity in the stratum at the upper boundary of the mantle at a depth of 100 km.

After the second reaction zone, if the matter still contains metal carbides, nitrides, phosphides and sulphides that have not undergone hydrolysis, as indicated by the composition of the stony meteorites and chondrites then all this matter, except for the sulfides, is lacking in the Earth's crust. This may indicate a *third reaction stratum* enroute from the second reaction zone toward the crust, in which a complete hydrolysis occurs of the primary planetary matter compounds such as metal carbides, nitrides and phosphides and an incomplete hydrolysis of the metal sulfides. At some depth of the upper mantle, the ratio of temperature to pressure is such that the metal hydroxides can be dehydrated. The liberated water hydrolyzes the compounds involved in this process and also dissolves the easily soluble silicates of the alkali metals. It is due precisely /38 to such processes that the formation of matter corresponding to the composition of carbonaceous chondrites and tektites becomes possible. In carbonaceous chondrites the carbon content may reach 5% and the water content, 20%. In tektites the amount of alkali metal is close to that in the crust. It is the sharp change in the matter and the energy yield from the chemical reactions that distinguish the third reaction stratum from the other contiguous strata, particularly in seismic velocities. It is only natural and logical to assume that the waveguide with reduced seismic velocity, located in the upper mantle at a depth of 60 - 200 km, is simply a third reaction stratum of the Earth.

The distinguishing feature of the waveguide material is not only that matter having the composition of carbonaceous chondrites and tektites is found here, but also that the waveguide material is enriched with gases of methane, ammonia, phosphine and hydrogen sulfide. The simultaneous hydrolysis of carbides, nitrides and sulfides led not only to the formation of hydrocarbons but also to the formation of their nitrogen, sulfur and oxygen derivatives, i.e., those elements which make up petroleum. The plastic nature of the waveguide material makes possible an equalization of pressures from the crust by *shifting the mass of the matter horizontally*, and a build-up of the crust by *shifting the matter vertically*.

Rate of Deep-Seated Chemical Reactions

If we assume that internal activity in the Earth has been continuing for some 4.5 billion years and that during this time 64% of the planetary matter has undergone reaction, we see that deep-seated chemical reactions take place at the rate of $8.5 \cdot 10^{17}$ g per year. This is the average velocity rate. We must assume that the rate variations in individual micro-regions of the Earth are significant, *since the reacting mass is not a solution with freely catalyzing reaction agents*. When the flow rate of the process is sufficiently slow, no great temperature and pressure gradients develop in the reaction zone. The efflux of heat and reaction products from the reaction zone is uniform. In those regions of the reaction zone of the Earth, where the mechanical factor of matter displacement appears most strongly, the zone of the simultaneously reacting mat- /39

ter is expanded. Strong temperature and pressure gradients develop and the process assumes an evolutionary nature. This process can be resolved by allowing the superheated magma to flow through a gap to the contiguous zones of the mantle and the crust, thus relieving the pressure. This eruption is accompanied by an earth-quake. The force of the earth-quake is found to be in direct dependence on the dimensions of the reacted matter involved in the evolutionary process.

The fact that the process did not take on a volcanic nature, i.e., that the magma only approached the surface of the crust rather than erupting onto it, may indicate that the intensity of the subterranean process might have been insufficient.

In our opinion, earthquakes (especially the Tashkent earthquake of 1966) can only be explained by the chemical processes occurring in the waveguide.

Jeffreys [1960] adheres to Reid's definition of an earthquake: an earthquake is a fracture which occurs as a result of long-term stresses. In this definition, no reason is given for creation of the stresses and no explanation is made as to why these pressures arise and recur locally, being confined to rather definite levels.

Seismic centers must be distributed in three reaction zones on Earth at depths of 60 - 200, 900 - 1000 and 2800 - 2900 km and above these levels in bands where the magma which has flowed from the reaction zones has accumulated. In fact the seismic centers have been determined: surface centers in the Earth's crust, intermediate centers at depths no greater than 300 km and deep-seated centers at a depth of 720 km [Aprodiv, 1965]. In fact, the most deeply seated earth-quakes at the levels of the first and second reaction zones have not been detected. A probable explanation for this is that the seismic waves from the greater depths are attenuated before they reach the surface of the Earth.

The evolutionary processes which take place in the third reaction zone may be halted not only by eruption into the contiguous zones of the mantle and the crust, but also by eruption onto the surface of the crust. This type of evolutionary process is called volcanic. It is not merely accidental that the seismic centers and the volcanic centers are confined to the third reaction stratum or to the zones found above this stratum where the magma has accumulated. ^{/40} These and other phenomena have a common cause - deep-seated chemical reactions. The recurrence cycle of earth-quakes and volcanic eruptions are most strictly related to the duration of the chemical processes and, in proportion to these processes, to the accumulation of new portions of the depleted matter and new portions of the chemical reaction energy.

Since earthquakes are caused by deep-seated chemical processes, a relationship exists between the geographical distribution of

seismic centers, their number and the rotation of the Earth on its axis and the annual revolution of the Earth around the Sun. Geographically, the seismic centers are distributed in the form of chains, extending from the equatorial zone toward the polar zones.

With respect to the relationship of earthquakes with the annual revolution of the Earth around the Sun, V.A. Magnitskiy [1965] writes the following: "At the present time, the greatest attention is being given to the relationship between the number of earthquakes and the revolution of the Earth around the Sun. Of all other relationships, this one can be shown statistically with the greatest reliability. However, the nature of such a relationship, if in fact one does exist, is still quite obscure. All the causes cited above produce stresses on the order of 10^4 - 10^5 dyne /cm², whereas earthquakes are created at stresses that are at least two to three orders greater. It is not understood, given such a relationship, how these causes could even produce a trigger mechanism." As a "cause" the tectonic activity of the Earth is implied.

In our opinion, the internal activity of the Earth, which is particularly manifested in earthquakes and volcanic activity, is related to the deep-seated processes, the rate of which gives a mechanical factor such as the mixing of the reacting matter. When the Earth rotates around its axis, a pressure is created on the equatorial part of the waveguide material. This pressure is transmitted along the waveguide toward the polar zones. As a result, chains of points (centers) are formed along the meridians at an accelerated reaction rate. When the Earth revolves around the Sun, pressures are not created along the meridian as is the case when the Earth rotates on its axis, but rather they are created along the parallels. The movement of plastic matter in this new direction is accompanied by /41 an increased rate of the deep-seated chemical processes and consequently by an increased internal activity in the Earth.

The relationship between the internal activity of a body and its rotation about its axis and its center of gravity is seen with special clarity in bodies that have a large mass, for example, Jupiter and the Sun.

Directions of the Deep-Seated Chemical Reactions

The occurrence of deep-seated chemical reactions at different rates may mean that it is the same reactions which are occurring, but under different temperature and pressure conditions. At a high reaction rate in a given zone, elevated temperatures and pressures are created. We can not exclude the possibility that increases in temperature and pressure may change the direction of these reactions. A good example of this can be seen in the hydrolytic reaction of calcium carbide [Bisalsky, Eck, 1928]. Under normal temperature conditions, this reaction occurs exclusively with the formation of the hydrocarbon, acetylene. As the temperature climbs, the yield of hydrocarbon decreases, but the yield of carbon dioxide increases. At a temperature of 450° C calcium carbide hydrolyzes exclusively

with a carbon dioxide yield. Consequently, calcium carbide hydrolyzes as a function of temperature in two directions: *to hydrocarbon and to carbon dioxide*. At intermediate temperatures, the process may take place simultaneously in both directions.

It must be assumed that in the deep-seated hydrolytic processes with certain well-defined temperature/pressure ratios, this process will take place either in a given direction, in another given direction or in both directions simultaneously. When the temperature/pressure ratio is reduced, the process will occur in the direction of hydrocarbon with the formation of gases such as methane, ammonia, phosphine and hydrogen sulfide from the carbides, nitrides, phosphides and sulfides. When the temperature/pressure ratio is raised, the process takes place in the direction of carbon dioxide, with the formation of carbon dioxide and sulfur dioxide as well as nitrogen. At intermediate temperature/pressure ratios the process takes place simultaneously in both directions, and gases from both directions /42 are created. Below we will show that their total yield will be 6.11% for nonvolatile magma and a nitrogen/sulfur/phosphorus/carbon/water ratio of 1:2:3:10:148.

A plastic waveguide matter, which is a system of a solid dispersed medium and a gaseous dispersed phase, is differentiated in stages during its migration from the waveguide to the crust. The gaseous mixture is separated out of the solid medium at some stage of differentiation. Then during condensation of the water vapors, the gaseous mixture is converted to an aqueous solution of gases. The highly water-soluble gases, i.e., ammonia, hydrogen sulfide and sulfur dioxide, continue to be in solution in proportion to the amount by which the pressure is reduced in the crust; the poorly water-soluble gases, i.e., methane, carbon dioxide and nitrogen, are separated out of solution either partially or completely.

If the gases have been formed in the wave guide at relatively low temperatures, their initial composition may be the following: methane, ammonia, hydrogen sulfide and phosphine. By differentiation of the gas mixture enroute toward the surface stratum of the crust, the ultimate composition of the gas may be only *methane*. Such natural gas is called a hydrocarbon.

In the other extreme case, if the hydrolytic reaction takes place under elevated temperature conditions, the initial composition may be the following: carbon dioxide, sulfur dioxide and nitrogen. In the process of migration, the sulfur dioxide and a part of the carbon dioxide are lost and the final composition of the gas will be *nitrogen-carbon dioxide*. The nitrogen/carbon dioxide ratio will depend on how much carbon dioxide has dissolved enroute.

In the intermediate cases, when the hydrolytic reaction takes place at medium temperatures, the initial composition of the gas mixture will be the following: methane, ammonia, hydrogen sulfide, phosphine, carbon dioxide, nitrogen, sulfur dioxide, phosphorus

oxides and water vapors. From this complex gas mixture there may ultimately be created *hydrocarbon-carbon dioxide or nitrogen-hydrocarbon*. This all depends on which direction predominates in the reaction. If the hydrocarbon direction has predominated, it will have been accompanied by a high methane and ammonia yield and a small amount of carbon dioxide and nitrogen. With this initial composition of the gas, the ammonia and carbon dioxide will be lost and the final gas will consist of hydrocarbon and nitrogen. If the carbon dioxide direction has predominated during hydrolysis, the methane yield must be lower and the carbon dioxide and nitrogen higher. If only a small amount of carbon dioxide has been dissolved enroute, the final composition will be characterized by hydrocarbon and carbon dioxide. If the carbon dioxide has been lost enroute, the final composition of the migrating gases will be *hydrocarbon-nitrogen*. /43

Let us note that there is no necessity for assuming that chemical changes will take place under the conditions existing in the crust in order to assure that the different compositions of natural gases will occur. If the deep-seated gases had manifested sufficient chemical stability under the conditions existing in the waveguide, they would then retain this property to a significant degree under the conditions found in the crust.

Energy of Deep-Seated Chemical Reactions

The temperature distribution in the Earth depends to a significant degree on the intensity of the energy sources and their distribution in the interior of the planet. At the present time all authors involved in solving this problem assume the energy of radioactive decay to be the main source of the Earth's heat.

All existing methods for determining temperatures of the Earth have to some degree limited applicability. Some of the methods, in the opinion of I. Verkhugen [1958] simply can not be used. It is characteristic that a rather wide range of discrepancies exists among the different methods and authors. For example, the results of determining the temperature of the Earth's core range from 2000 to 10,000°C.

The information available on the distribution of radio-active matter at different depths in the Earth does not simplify the solution to the problem. Moreover, the facts known about the Earth's radioactivity do not correspond with those known about its internal activity. If the internal activity of the Earth were connected with the phenomenon of radioactive decay energy, then our observations in this area would be sharply contrasted to those conditions which actually exist.

From radiochemical analyses of different rocks, as well as from /44 stony and iron meteorites, we see that the greatest concentration of radioactive matter is in the granite layer of the Earth's crust. This phenomenon is easy to understand in the light of the great speed at

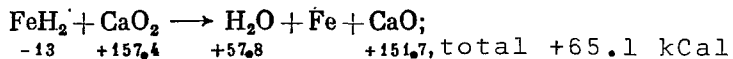
which the volatile and fusible matter migrate to the surface of the Earth. Included in these are numerous uranium compounds. Assuming the position that the increased concentration of radioactive matter occurs in the crust, it would be natural to assume the Earth's internal activity to be in the crust rather than in the mantle. The radiological hypothesis *does not correspond* either to the existence of shallow or of deep-seated earthquakes.

Furthermore, if we assume the heat flux through the continental crust to be determined by the presence of high concentrations of radioactive matter in it, then the heat flux through the oceanic crust must be weaker since no granite layer exists there. However, these assumptions have *not been confirmed*. Based on the data from determining heat fluxes at 5 points in the North Atlantic and at 6 points in the North Pacific Oceans, the mean value for the heat was very close to the continental values [Verkhugen, 1958].

We know that the deep-seated processes have afocal character. If the characteristic processes are defined by the concentration of deep radioactive matter, we would then observe an increased radioactive background with an increased amount of radioactive matter in the igneous rocks during volcanic eruptions. In fact, this *is not observed*. Products of volcanic eruptions bear no noticeable traces of a radioactive effect.

It is known that during eruptions involving volatile matter, the maximum yield drops for water, but not for a mixture of hydrogen and oxygen. Radioactivity can cause only dissociation of water into hydrogen and oxygen, but not association of the latter with the formation of water.

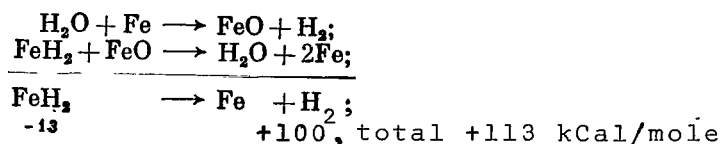
Thus, explaining the internal activity of the Earth by the energy of radioactive decay *does not reveal*, but rather conceals its essential characteristics. The chemical nature of the internal activity is confirmed on the Earth's surface in the form of a number of compounds in their given ratios. The total amount of water entering the surface may indicate a deep-seated chemical process of water formation and the energy yield from this chemical reaction. The reaction of water formation from iron hydride and calcium peroxide is assumed to be an exothermic reaction: /45



The reactions of forming silicates are large both in size and calorific value. Thus, for example, the formation from oxides of a silicate having the composition $\text{K}_2\text{O} \cdot \text{Al}_2\text{O}_3 \times 6\text{SiO}_2$ is accompanied by a yield of 131.2 kCal/mole.

The reaction of forming gaseous hydrogen based on heat production

is also quite effective:



Based on a calculation given earlier (Table 14), the total amount of hydrogen given off is equal to 1.237% of the total mass of the Earth. Of this amount of hydrogen, 0.097% is involved in the production of water. Therefore, $6.85 \cdot 10^{25}$ g of gaseous hydrogen could be liberated. This means that for the time of the internal activity of the Earth with the water-production reaction, an energy of $3.87 \cdot 10^{30}$ Cal was given off. This reaction continues until the internal activity of the Earth ceases and an additional $2 \cdot 10^{30}$ Cal is liberated. Thus we find that *each gram* of the total mass of the Earth liberates 1000 Cal of heat.

According to Ye. N. Lyustikhu (1959), losses in the Earth's heat due to thermal conductivity amount to approximately $4 \cdot 10^{20}$ Cal/yr. If we assume the time of the internal activity in the Earth to equal 4.5 billion years, the total loss of heat then amounts to 1.8×10^{30} Cal. According to the estimates cited, the *influx and efflux of heat on Earth agree quite well*.

Properties of Deep-Seated Chemical Reaction Products

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Decrease in the Volume of the Reaction Products

The basic reaction in the first reaction stratum of the Earth is accompanied in final analysis by the conversion of iron dihydride into metallic iron. Such a conversion may be combined with a significant *contraction in the volume*. During the time of internal activity in the Earth, $2.16 \cdot 10^{27}$ g of iron, nickel and cobalt dihydrides were subjected to decay. The specific gravity of iron dihydride is 2.9 g/cm^3 . Therefore, the initial volume of the expended iron dihydride was $0.74 \cdot 10^{27} \text{ cm}^3$. As a result of its decay, $2.09 \cdot 10^{27}$ g of metals were created. Since the specific gravity of iron is 7.9 g/cm^3 , this mass of metal could occupy a volume equal to $0.26 \cdot 10^{27} \text{ cm}^3$. Hence it follows that as a result of one of these reactions the volume of the reaction products decreased by $0.48 \cdot 10^{27} \text{ cm}^3$.

Since the process involved in diminishing the volume of matter in the Earth begins in the first reaction stratum, this change must affect the planet quite deeply. Beginning from the core it is quite probable that all matter in the upper and lower mantle, as well as that in the crust (as it subsided to the level of a smaller radius) underwent deformation.

Increase in Pressure Caused by the Reaction Products

The process, by which metal dihydrides of the iron family are decomposed in the first reaction stratum of the Earth, is accompanied by the release of gaseous hydrogen. On the whole, $6.85 \cdot 10^{25}$ g of hydrogen were released. This liberated gas did not expand the volume of the Earth but rather created a *pressure* which gradually diminished as the hydrogen escaped into the Earth's atmosphere. The total amount of hydrogen that traveled from the first reaction stratum was about $8 \cdot 10^{26}$ liters under normal conditions.

The process of hydrogen migration through matter in the mantle and the crust can only be assumed as one of the manifestations resulting from internal activity in the Earth. It is quite possible that this process plays a significantly larger role in the physical and chemical behavior than would be assumed at first glance. We must assume that the reducing medium in the interior of the Earth is associated with the presence of hydrogen there.

We should note that many authors, who deny the possibility that /47 a decrease in the volume of the Earth may be associated with the chemical processes, do admit that the chemical processes may take place with an increase in volume. The reaction involved in water formation is precisely such a case where the volume of gas increases, but nevertheless as a result the volume of the Earth not only does not increase but significantly decreases. Here we can compare the occurrence of eruptive reactions in a closed space, where the reactor walls do not expand as the pressure inside it increases.

Increase in Temperature in the Reaction Strata of the Earth

Three reaction strata are found in the Earth. Chemical reaction energy is given off in each of them, and consequently each produces conditions that cause a temperature gradient between the upper and lower strata. The amount of the temperature gradient is determined by the size of the reactions and their calorific value. We must expect the greatest temperature gradient to be in the first reaction stratum, the center of which is located at a depth of 2900 km. The curve plotted for temperature versus depth can not be flat on this segment. Here there must be a rise with a subsequent drop somewhat below the boundary of the core.

A less significant temperature gradient with the contiguous strata must be observed in the second reaction stratum, the center of which is located at a depth of 900 km. Here the hydrolysis which occurs is significantly less than the reduction-oxidation processes that occur in the first reaction stratum, with respect to size and heat release. On this segment the temperature curve may rise slightly and then slope down under the upper boundary of the lower mantle.

In the third reaction stratum, located at a depth of 60-200 km,

we find the occurrence of large-scale hydrolytic processes. In this stratum the temperature must again be higher than in the lower and higher strata. It is possible to judge the temperature of this stratum from the temperature of the volcanic magma, whose center is found at precisely this depth. If the temperature of the magma is 1100°C , the temperature in the center may be on the order of $1200\text{--}1300^{\circ}\text{C}$ at a depth of 200 km.

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Elevated temperatures in the reaction strata, combined with changes in the chemical composition of the matter, lower the density of the strata. This decrease is stronger as the composition of more of the matter is converted and the temperature of the stratum becomes higher. The seismic velocity, depending on the density of the medium, drops in the first reaction stratum from 13.6 to 8.0 km/sec. In the second reaction stratum, if no drop is observed in the curve for the seismic velocities, the curve will not rise in the segment above 100 km. Seismic velocities in the range of depths from 780-900 km remain at a constant level of 11.4 km/sec. In the third reaction stratum there is a drop in seismic velocity from 8 to 7.4 km/sec. This drop may seem small. However, this is not so. Let us compare the velocities at different depths. As we go from 60 to 200 km through matter that is uniform in density, the seismic velocity would increase from 8 to 9 km/sec. Therefore, the actual decrease in seismic velocity would be by 1.6 km/sec rather than 0.6. Different authors place different interpretations on the nature of this stratum of the mantle where the seismic velocity characteristics are anomalously low. For example, K. L. Cook [1962] attributes the phenomenon of reduced wave velocities to the rocks from the mantle being mixed with the rocks from the crust. According to this concept, it would appear that the rocks from the crust sink to a depth of 200 km, and in certain zones even lower where the waveguide subsidence sometimes reaches to 400 km. It is difficult to agree with such a concept.

B. Gutenberg [1926], having detected a zone of low wave velocities for the first time, believes this phenomenon to be associated with problems concerning the Earth's origin. According to his concept the Earth was ejected from the Sun and has still not cooled completely. Those zones of the Earth which have still not cooled possess a smaller elasticity of matter. This concept is supported by Jeffreys [1960]. Apropos of this problem, Jeffreys says the following: "From my point of view, the presence of a granite stratum and the concentration of radioactive matter on a comparatively thin stratum near the surface is a decisive reason for favoring the concept that the Earth was formerly liquid."

We can agree partially with Jeffreys since the matter in the Earth's crust actually bears signs of having been crystallized at high temperatures, but our opinions differ with respect to a hot origin of the Earth itself.

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The existence of three reaction zones (three waveguides with elevated and high temperatures) in the planet and existence of the

continual process of absorbing newer and newer portions of planetary matter into the waveguides, as well as the ejection of reaction products from them, would cause us to conclude that the *Earth had never been in a liquid state*, but that a large part of its matter had passed through the stage of melting in the reaction zones of the Earth at one time or another. If the problem is formulated in this manner, it is obvious that those studies, which accurately prove that the Earth's rocks originated from a melted state, cannot be used to prove that a "liquid" Earth existed in the past.

It seems to us that V. A. Krat [1961] is correct when he says: "The Earth was never in a melted state, but virtually all of its parts have undergone melting at one time or another."

Creation of Electromagnetic Phenomena in the Reaction Zones of the Earth

The question of the physical state of plastic matter in the reaction zones, i.e., waveguides, is of special interest. Under the conditions of a strong rotation of the Earth the planetary matter in the waveguides cannot remain stationary, and its motion can not produce friction between strata nor can it produce the resulting electromagnetic phenomena. Much of what is known about the magnetic properties of the Earth would tend to show that it is not the core that is the source of electromagnetic phenomena but rather the *waveguides*. In this light, the magnetic field of the Earth would appear unstable both in intensity and direction of the magnetic axis. These characteristics are quite closely related to the mass and form of the waveguides, as well as to the rotational velocity of the Earth. However, no characteristics remain constant.

The 11° deviation of the magnetic axis from the rotational axis of the Earth, which is observed at the present time, can be explained by a deformation of the waveguides. The sharp and spasmodic changes in magnetic intensity in seismic regions prior to earthquakes can be explained by the velocity and direction of movement of the waveguide masses under these regions. Paleomagnetic studies give numerous examples of directional changes in intensity of the Earth's magnetic field. /50

If the model of the Earth, having the electromagnetic properties described above, is applicable to the other planets, we must assume that the other planets are also magnets. However, as American investigations have stated, there is no magnetic field on Venus. But if the magnetic field of a planet is related to the core, then Venus would have to have a magnetic field since the assumption of an iron core in Venus is based on a very important characteristic, i.e., the high mean density. The reason for no magnetic field on Venus is probably due to the insufficient rate at which the plastic matter in its reaction strata moves in the waveguides. The rotational period of Venus is believed to be in the hundreds of Earth days. At such a rotational rate, there is insufficient motion of the plastic

matter in Venus' waveguides to produce any observable electromagnetic phenomena.

If the magnetic field of the Earth were due to the existence of a liquid core then it might be possible to explain the absence of a magnetic field on Venus by the existence of a solid core. But explaining an incomprehensible by an unknown then brings into sharp focus the question as to the state of the core of a planet; is it liquid or solid? V. A. Magnitskiy [1965] answers this question categorically: "In addition, we can now consider it to be an established fact that the outer core (2900-5100 km) is in a liquid state. The boundary between the mantle and the core is a sharply defined one." However, we have shown the existence of a sharply defined boundary between the mantle and the core on the basis of extreme chemical changes in matter, accompanied by strongly exothermic reactions. This is all reflected in the composition and structure of iron and stony meteorites. Here, we should note that the structure of the majority of iron meteorites indicates a conversion of matter from liquid to solid state under *conditions of slow crystallization*. On the other hand, the structure of the majority of stony meteorites indicated a rapid crystallization of the matter [G. S. Washington, 1949]. When the core of a planet is fractured the melt may be dispersed into numerous small parts. If these parts were cooled rapidly during the process, they could form in the shape of drops, reminiscent in form of tektites. It is understood in such case that the melt would have crystallized very rapidly. However, all that is known both quantitatively and qualitatively about iron meteorites, would not seem to indicate their formation from melted matter. They are not so numerous as tektites, nor so few as stony meteorites, but a slow cooling of their matter, and a crystallization characteristic of such a condition, could take place *only on the planet itself*. /51

The state of a planetary core depends on the temperature/pressure ratio in it. However, this ratio remains unknown to us. We can guess that the temperature in the core is high, but is it optimum for the Earth? Such a question is completely justified if we bear in mind that it is not the core but the reaction zone of the Earth, located outside the core, that is the source of the internal energy. Let us assume that the temperature of the core reaches 3000-4000°C. This exaggerated (in our opinion) core temperature is sufficient to melt metals at ordinary pressures. With pressures defined at millions of atmospheres (according to Bullen the pressure at the center of the core is 4.2 million atm), the density of iron is increased from 7.9 to 12. At such pressures we must exercise caution in evaluating the state of the core. However, leaving the realm of supposition with respect to the temperature and pressure, we are left with one very reliable fact, i.e., the *slow crystallization* of matter from iron meteorites does shed some light on the nature of the core.

Differentiation of Matter in the Earth's Mantle

The drop on temperature in the reaction strata is the motive force for differentiation of matter in the Earth's mantle. In these strata the "forge", from which matter emerges in the form of a melt, is in constant operation. With further gradual cooling of the melt the matter is redistributed by its melting points. Thus, the differentiation of matters occurs mainly during zone melting. In the most common form, the following tendency appears: metals subside and slags float. In the initial cooling stages of the melt the matter is redistributed by fractions with melting points encompassing a wide range. The composition of iron-stony meteorites, in which metals and metal oxides are combined, may be examples of this. In subsequent cooling stages of matter, fractions appear with melting points confined to a narrow range. Iron meteorites and stony meteorites which were probably created from iron-stony meteorites, may serve independently as examples. It is possible, by calculation, to derive two daughter compositions from the parent iron-stony meteorite (pallasite): one undoubtedly the familiar iron meteorite composition and the other, in contrast, the stony meteorite composition. Such a calculation is given in Table 18, /52

Elements	Parent Composition of Pallasite, % 2.11 unit wt.	Daughter Compositions, %	
		Iron Meteorite 1 unit wt.	Stony Meteorite 1.11 unit wt.
Fe	55.3	90.67	22.94
Ni	5.4	8.5	2.56
Co	0.3	0.59	0.04
Mg	12.3	—	23.40
Si	8	—	15.20
O	18.5	—	35.10
Other . . .	0.2	0.2	0.20
Total .	100.0	99.96	99.54

In turn, the incipient primary compositions which are responsible for the stony meteorites, with further cooling of the melt, yield fractions with increasingly narrow ranges of melting points. We can represent decomposition of the original composition of stony meteorites by the two daughter compositions responsible for meteorites with a finer differentiation of matter. Such a stratification of matter is given in Table 19 on the basis of calculations.

In this calculation, composition I (representing a known tektite composition, i.e., billitonite, was necessarily introduced [Krinov, 1948].

V.A. Magnitskiy [1964] showed experimentally that it is possible to obtain two new compositions by the zone melting of a stony meteorite. One of them is close to the composition of light rocks in the Earth's crust, the other to dunites and peridotites. /53

Elements	Composition of Original Stony Meteorite, wt. %, 27.43 unit wt	Compositions of Daughter Stony Meteorites, wt, %	
		I 1 unit wt.	II 26.43 unit wt.
Fe	15.1	4.22	15.5
O	41	47.9	40.7
Mg	14.3	1.57	14.8
Si	21	32.18	20.5
Al	1.56	7.29	1.3
Ca	1.8	2.78	1.8
Na	0.8	1.26	0.78
K	0.07	1.92	—
Total	95.63	99.12	95.38

We must assume that the different classes of meteorites do not reflect the composition of a planet in general, but that each class reflects the *composition of planetary matter at a given depth*, at a definite stage of differentiation.

In light of this it is possible, based on data from meteorites, to construct a *chemical model of the earth* (Table 20).

In this table the strata and substrata of the Earth's mantles, excluding the crust, are designated by nomenclature of classes and groups of meteorites. The basic stratum of the lower mantle is called "cometic" since, in the author's opinion, comets must have the composition of primary planetary matter. The meteorite composition is taken on the basis of literature sources [Krinov, 1949; Meyson, 1965]. Seismic velocity characteristics are taken mainly from A.A. Lyukk and I.L. Nersesov [Magnitskiy, 1965]. Temperature characteristics are taken mainly from Gutenberg [1949] with certain corrections. In particular, we took the temperature of 2000° C for the core from Gutenberg, and for the first reaction zone of the Earth at a depth of 2900 km we took the temperature of 3000° C.

The overall trends in depth distribution of matter in the Earth, according to the chemical model of the Earth, are the following:

1. Matter which differs in composition and is located at different depths, if found simultaneously under distinctly different

TABLE 20.

Mantles	Crust			Upper				Mantle						Lower Mantle	Core				
Reaction Strata								III					II		I				
Strata by Composition	Sedi-mentary	Gran-itic	Basal-tic	Achondritic				Chondritic						Com-etic	Iron-stony	Iron			
Substrata	—	—	—	Hypersthenic	Proxene plagioc-lastic	Dio-pside-olivine	Augitic	Carbon-aceous	Tektitic	Olivine-pigeonitic	Olivine-hypersthenic	Olivine-bronzitic	Enstatitic	Primary Planetary Matter	Mesosider-ites	Pallasites	Hexahedral	Octahedral	Ataxitic
Mass, wt. %	0.1	0.2	0.2	4.0				24.5						36		35			
Lower Boundary, km	5	15	35	60				110	130	200	400	700	780	1000	2900	6370			
Seismic Velocity, km/sec	5.5	6.3	7.3	8				8.7	7.5	8.7	8.9	10	11.4	13.6	8	11.3			
Density, g/cm ³			3.32	3.35				3.47		4.6				—		5.6	12		
Temperature °C	100	375	1000					1300		1500				1800		3000	2000		
Pressure, Million atm.	—			0.016				0.3						1.3		4.2			
Composition																			
Fe	—	—	—	—	—	—	—	—	—	5.2	4.0	6.2	15	23.7	—	43	55	93	85
Ni	—	—	—	—	—	—	—	—	—	0.2	1.4	1.3	1.8	1.7	—	3.9	5.4	8	14
SiO ₂	70	59	49	53	49	49	45	28	70	39	34	40	36	38	22.7	24	17	—	—
Al ₂ O ₃	13	15	15	1.5	11	1.7	8.8	2	12	0.6	2.1	1.8	1.9	1.7	4.6	5	—	—	—
MgO	1	3	6	26	11	12	10	19	3	36	23	24.7	23	21.6	7.5	7	20	—	—
CaO	2	4	9	1.4	10	15	24	1.6	3	1.4	2	1.7	2.4	1.0	—	4.5	—	—	—
FeO	5	6	10	17	17	19	8.5	27	6	13	24	15	10	0.2	—	4.8	—	—	—
Na ₂ O	0.8	4	3	0.5	0.5	0.4	0.3	0.5	1.7	0.4	0.7	0.7	0.7	0.6	0.2	—	—	—	—
K ₂ O	1.9	3	1.5	—	0.1	0.14	0.2	—	2.3	—	—	0.2	0.1	0.1	—	—	—	—	—
H ₂ O	5.5	5.5	—	—	—	—	—	12.8	2.3	—	0.1	0.2	0.2	0.3	—	—	—	—	—
C	0.35	0.35	—	—	—	—	—	2.5	—	2.26	0.2	0.03	—	0.32	—	—	—	—	—
Total Fe	3.7	4.4	7.3	13	13	15	6	21	19	15	23	18	23	24	52	47	55	93	85
Total O	49	44	43	45	42	40	41	30	48	39	35	35	32	30	19	20	18	—	—
Density of Meteorites g/cm ³	—	2.6	2.9	—	3.25			—	—	—	3.54	—	—	—	2.9	4.8	5.4	7.72	
Number of Meteorites by Group	—	—	—	2	39	2	1	17	—	3	12	159	80	11	—	40	22	55	391
Number of Meteorites Found, by Class	—	—	—	64				954								545			

/55

/54

conditions of temperature, pressure and water content, thus produc-^{/56}
ing those differences in the crystal structure of planetary matter
found in stony and iron meteorites. The structure of matter in iron
meteorites, in contrast to stony meteorites, is characterized by slow
crystallization. A finer distinction is reflected in the structure
of matter in stony meteorites. Chondrites are distinguished from
achondrites by the presence of chondrules in their structure. The
crystal structure of carbonaceous meteorites has a transitional
nature. Also among those meteorites included in the class of chon-
drites are those which do not have chondrules. This phenomenon is
easily explained if we bear in mind that a carbonaceous substratum
is situated at the boundary with the achondritic stratum.

2. The upper boundary of nickelous iron in the Earth begins
at a depth of 200 km from the olivine-pigeonitic substratum of the
chondritic stratum. In the chemical model of the Earth for the
olivine-pigeonitic substratum two columns of figures are given:
one for 12 meteorites (chondrites), and the other for 3 meteorites,
in our opinion erroneously including achondrites. In these three
meteorites the nickelous iron content is characteristic of chon-
drites rather than of achondrites, the absence in them of chondrules
being due to the proximity of the olivine-pigeonitic substratum to
the achondritic stratum. The bases for including these three mete-
orites in the chondrites are the same as those on which the car-
bonaceous meteorites without chondrules are included in the chon-
drites.

3. In proportion to depth, the nickelous iron content systemati-
cally increases, reaching a maximum value in the hexahedral sub-
stratum of the iron stratum. At a greater depth toward the iron
stratum the nickelous iron components are redistributed and the
nickel content is increased at the expense of iron. The nickel
content may reach 60% in ataxites.

The ferrous oxide content reaches a high value in the olivine-
pigeonitic substratum of the chondritic stratum. In the carbonac-
eous substratum the ferrous oxide content has a maximum value of
27%. This is reached, in our opinion, by redistribution of the
matter with the contiguous tektite substratum. From the carbonac-
eous substratum upward and downward there is a decrease in the fer-
rous oxide content. A sharp jump is noticed at the upper boundary
of the mantle. The ferrous oxide content drops from 17% in the
mantle to 10% in the basaltic stratum and to 5% in the sedimentary
stratum.

^{/57}

4. With a high silicon dioxide content in all strata of the
upper mantle there is a definite tendency for an increase in quan-
tity as the depth decreases. In the sedimentary stratum of the
crust the silicon dioxide content reaches a maximum value of 70%.
In two substrata of the waveguide (carbonaceous and tektitic) the
silicon dioxide was redistributed. Because of the decrease in
silicon dioxide content in the carbonaceous substratum, there is a

greater amount in the tektite substratum.

5. With very insignificant amounts of aluminum oxide in many substrata of the upper mantle, its concentration is sharply increased in all strata of the crust. The tektitic stratum in this case is distinguished by the amount of aluminum oxide that is found at the level of the sedimentary stratum of the crust.

6. The picture of the magnesium oxide distribution to a great extent is reminiscent of that observed with ferrous oxide. Magnesium oxide, reaching a very high concentration of 36% in the olivine-pigeonitic substratum decreases further away in both directions. In the mantle, at the boundary with the crust we find 26% magnesium oxide, while in the crust a sharp drop in concentration occurs: in the basaltic stratum we find up to 6%, and in the sedimentary stratum up to 1%. In the waveguide we also find a magnesium oxide redistribution; its concentration in the carbonaceous substratum increases as a result of the decrease in the tektitic substratum.

7. The high calcium oxide content is confined to the achondritic stratum. Upward and downward from it the calcium oxide content decreases.

8. Low concentrations of alkali metal oxides in many strata of the upper mantle are matched by a rather high content in the crust and the tektitic substratum. The increased amount of alkali metal oxides in the chondritic stratum, as opposed to the achondritic stratum, is worthy of attention. The alkali metals were enriched in the tektitic substratum due to their depletion in the achondritic stratum.

/58

9. For the distribution of light elements and their compounds, just as for the distribution of alkali metals, two optima are characteristic (in the crust and in the carbonaceous substratum). In the enstatitic substratum of the chondritic stratum, carbon, nitrogen, phosphorous and sulfur are found in compounds, while keeping their lower valency. The concentration of these elements in the enstatitic substratum is very close to, or even coincides with, those which result from the mean composition of the upper mantle. As the concentration of light elements and their compounds travel upward, the form of existence of the matter changes sharply. All these accumulated changes are most clearly expressed in the carbonaceous substratum. Here up to 5% carbon is detected in the form of high-molecular hydrocarbons and their heteroderivatives, i.e., graphite and diamonds, calcium carbonates, magnesium and iron. The concentration of nitrogen reaches 0.29% and is present in the form of derivatives of hydrocarbons and ammonium salts. The sulfur content reaches 6.6%; of this 1% is free sulfur and the remainder is in the form of sulfur derivatives and sulfates. Of the sulfates, gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) and epsomite ($\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$) are found. The phosphorus content is 0.13% and exists in the form of phosphates. The water content in the carbonaceous meteorites is high. In certain

cases the amount of free water may reach 20%. We must assume that even more water is found in the bound state. Only for carbonaceous chondrites is the presence of hydrated forms of salts characteristic: gypsum, epsomite and serpentine.

Of the minerals from meteorites the most widely distributed is olivine, $(\text{Mg,Fe})_2\text{SiO}_4$, and in second place is rhombic pyroxene, $(\text{Mg,Fe})\text{SiO}_3$. If we bear in mind that for the formation of a molecule of serpentine $6\text{MgO} \cdot 4\text{SiO}_2 \cdot 4\text{H}_2\text{O}$, four molecules of water are expended, it is easy to imagine how great is the total expenditure of water with such an abundance of magnesium silicates in the strata of the mantle.

It is important to note that in the carbonaceous substratum we first find the carbonates, sulfates and phosphates, which could have been created at the depth of the waveguide with high-temperature hydrolysis of the carbides, nitrides, phosphides and sulfides of metals. These processes are also involved in expenditure of the deep-seated water. In Table 20 no water content is shown in the tektitic substratum since the water evaporates with the formation of meteorites - tektites. We must consider this water in the overall balance.

Of the light elements it is only oxygen as a true indication of depth, beginning from zero at the boundary of the iron stratum and gradually increasing, which scrupulously reaches 49% in the sedimentary stratum of the crust. The tektitic substratum and the oxygen content which is found at the level of the sedimentary stratum of the crust, is an exception. This is not accidental since the Earth's crust is formed by matter from the waveguide. The plastic matter in the waveguide, by intrusions and volcanoes, penetrates the crust and forms it. /59

Not one component of the Earth's matter remains constant at all depths. The concentration of individual components at different depths is determined by the temperature and pressure existing in them.

TABLE 21

Oxides	Mean Composition, wt. %		II/I Ratio
	Matter in the Upper Mantle I	Volcanic Rocks II	
SiO_2	50.0	59.1	1.2
Al_2O_3	10.1	15.3	1.5
MgO	16.6	3.5	0.2
FeO	6.4	6.6	1.0
CaO	4.7	5.1	1.1
Na_2O	1.86	3.8	2.0
K_2O	1.6	3.1	2.0

To be certain that the variations shown in Table 20 are correct for the depth distribution of matter in the Earth we must compare the composition of the volcanic rocks which appear on the Earth's surface (Clark, 1924) with the mean composition of matter from the upper mantle (Table 16). Such a comparison is given in Table 21.

The comparison of compositions for such a specific case also confirms the overall tendency in the depth distribution of matter that was determined from the chemical model of the Earth; with a decrease in depth, the amount of silicon, aluminum, potassium, sodium and calcium oxides increases.

A comparison of the composition of matter reaching us by different means, but from the same depth (from the third reaction stratum) may serve as additional confirmation of this conclusion. This matter comes in the form of intrusions from that stratum, as a result of which the crust is built up from below. In addition, matter from this stratum enters by volcanic eruption thus adding to the crust from above. If we also bear in mind that the meteorite-tektites, which fall on the surface of the Earth, reflect matter from the third reaction stratum, in our view then there are three types of matter that arrive by three different routes. Though they arrive by different routes, their origin is the same. In light of this, the similarity in the compositions of rocks from the Earth's crust, volcanic rocks, and tektites is not an accident. Their compositions are given in Table 22.

/60

Elements	TABLE 22 Mean Content, wt. %		
	Earth's Crust	Volcanic Rocks	Tektites- Billitonites
O	49.16	46.25	47.9
Si	26.0	27.58	32.18
Al	7.45	8.10	7.29
Fe	4.2	5.24	4.22
Ca	9.25	3.65	2.78
Na	2.4	2.82	1.26
Mg	2.35	2.1	1.57
K	2.35	2.57	1.92

To require a greater similarity in these three compositions would not be valid since their method of arrival necessitates that their composition be slightly different. Furthermore, even samples obtained from the same zone might contain as many differences. If it were possible to extract matter from the third reaction stratum by a fourth method (superdeep drilling) we might then obtain matter having the same composition as volcanic rocks. Forgetting the problems involved in the technological feasibility of such a task

we would have to doubt its practicality since we do not know how such a canal would behave with respect to the third reaction stratum. We certainly can not eliminate the possibility that an artificial volcano would be created.

In light of the chemical model of the Earth given here, it is /61 possible to approach the problem of seismic wave velocity as a function of depth in the Earth from a somewhat different direction.

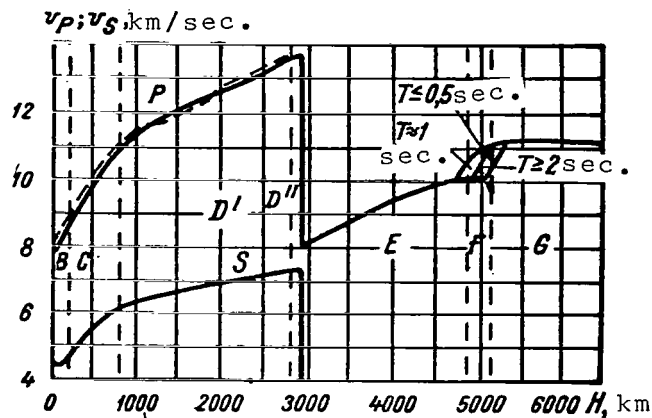


Fig. 1.

Figure 1 depicts curves reflecting variation by depth of seismic wave velocities. The velocities taken from Gutenberg's data are shown by solid lines, and those from Jeffrey's by the dotted lines. Stratum A (the Earth's crust) is not shown in the figure.

Figure 2 depicts the variation in velocity for the upper mantle obtained by A.A. Lyukk and I.L. Nersesov using a more precise method. The figures are borrowed from a book by V.A. Magnitskiy "Vnu-

trenneye stroyeniye i fizika Zemli" (The Internal Structure and Physics of the Earth) [1965].

It seems to us that a graph of seismic velocities should show a more sinusoidal curve than is represented in Figures 1 and 2. Conversions in composition of the matter must be reflected on a graph, not only at the boundaries of the Earth's mantles, but within these mantles, and at the boundaries between the strata and sub-strata of the entire mantle and the entire core. Iron meteorites, reflecting the composition of the core, give a basis for assuming that the core has a stratified structure and that the nickel content increases with depth. The possibility that the subcore consists of pure nickel can not be eliminated.

If we bear in mind that especially sharp conversions of matter, with respect to composition and chemical structure, are due to chemical reactions which are accompanied by an energy yield, then /62 the highest temperatures and the lowest seismic velocity indices must coincide in depth. Three temperature maxima and three seismic velocity minima must exist.

The Migration of Carbon

Let us attempt to trace a component of primary planetary matter such as carbon. In primary matter, carbon was found in the form

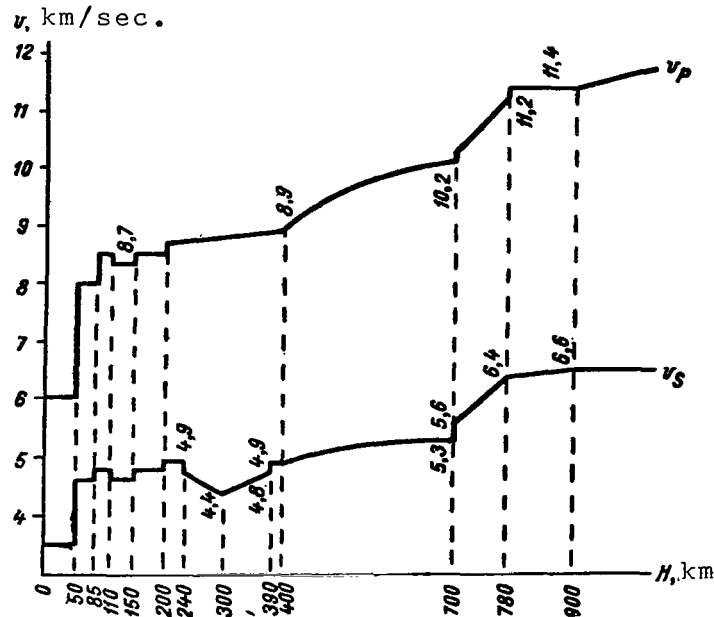


Fig. 2.

of iron, titanium and manganese carbides. The ratio of carbon content is 0.32% in the mass of the upper mantle and the crust. This figure is based on the calculations given in Table 16.

Let us see how well it agrees with the calculations of other authors. According to Clark [1924] the carbon content in magnetic rocks is estimated to be 0.13%. According to Fersman [1928] the carbon content in all meteorites is 0.13%. According to another estimate by Fersman [1953], the iron content in stony meteorites is 63 0.15%. According to Meyson [1965], in ordinary chondrites, the carbon content seldom exceeds 0.1%; as a rule it is significantly lower.

It should be noted at this time that a uniform carbon content can hardly be assumed in meteorites. On the contrary, since meteorites reflect the composition of planetary matter at various depths they must simultaneously reflect changes in composition by depth. Some meteorites reflect the composition of planetary matter prior to hydrolysis, others after partial hydrolysis and finally after complete hydrolytic processes. If we also bear in mind that compounds of carbon and hydrolytic products may undergo complete disproportionation, we can not eliminate the possibility that various

concentrations of planetary matter will be found at the same depth.

Our calculations indicate that matter which has not been subjected to hydrolytic processes must contain on the order of 0.31% carbon. In this case the carbon must be found in the form of metal carbides. We are then faced with the question: do the compounds of enstatite chondrites and certain olivine-pigeonitic chondrites, which are characterized by a carbon content from 0.3 to 0.5%, not appear mainly in this way? The composition of carbonaceous chondrites, containing up to 5% carbon, in our opinion must reflect the planetary matter that has been subjected to the processes of hydrolysis and disproportionation of carbon compounds and hydrolytic products. In this case carbon must be in the form of hydrocarbons and their derivatives, rather than in the form of metal carbides.

Meyson [1965], in attempting to evaluate the carbon content in primary meteorite matter, says the following: "Possibly the maximum amount of carbon in carbonaceous chondrites must be taken as the mean quantity in the primary meteorite matter, since all the processes involved in the chemical evolution of meteorites are obviously explained by the loss of carbon in the form of gases, such as CO and CO₂".

This evaluation by Meyson of the mean carbon content in primary meteorite matter completely disagrees with everything we have just said. According to our calculations the mean carbon content in matter from the upper mantle is 0.32%, and according to Meyson, it is 5%. Apart from the fact that our estimate follows logically from the entire system of calculations it also follows from the characteristics of matter in a planet. /64 Meyson's reference to the possibility of carbon loss in the form of its oxides seems invalid to us. On the one hand, at great depths carbon does not undergo oxidation, however, even if we assume such an oxidation, we must then also assume a very high yield of carbon dioxide on the planet's surface.

In studying the problem of carbon content in matter from the mantle, it is of special interest to establish the form in which it exists. Graphite is ordinarily assumed to be the matter of meteorites containing carbon; in very rare cases carbon is found in the form of diamond. Now it is clear that what was first thought to be graphite, with closer analysis is found to be simply organic compounds. Using sublimation and extraction by organic solvents, hydrocarbons and hydrocarbon derivatives of oxygen, nitrogen, sulfur and chlorine have been extracted.

S. Cloez [1864], in analyzing dark insoluble carbonaceous matter from the meteorite Orgueil established that this matter was organic rather than graphite or amorphous carbon. Analysis of this matter yielded the following composition (%): C-63.45; H-5.98; and O-30.57 (by differentiation). The matter was a polymeric compound with a high molecular weight.

J. Müller [1953] studied carbonaceous matter from the meteorite Cold Bokkeveld. Microanalysis of this matter yielded the following results (%): C-2.0; H-1.53; S-2.99; O, etc., 4.84 (by differentiation); inorganic radical - 89.44. Resin in the amount of 1.1% was studied by extraction. Analysis of the obtained mixture of matter yielded the following results (%): C-19.84; H-6.64; N-3.18; S-7.18; Cl-4.81; O, etc., 40.02; ashes-18.33. The components of the obtained mixture had different solubilities in the organic solvents. A benzene solution revealed no optical activity.

B. Nady, et al [1961] analyzed the organic compound from the meteorite Orgueil by a mass-spectrographic method and identified paraffin hydrocarbons in it in the range of C_{15} - C_{30} with peaks at C_{18} and C_{23} . In their opinion, there is a distinct connection between the manner in which these hydrocarbons are distributed and that which is observed in matter of biogenous origin.

/65

Claus and Nady [1961] assume the presence of "organized elements" in the meteorites Orgueil and Ivuna. They point out the imperfection of these "organized elements" and their similarity to mineral algae.

It is curious to note here the divergence in views between these investigators and adherents of the organic origin of petroleum. Adherents of the organic origin of petroleum do not admit the possibility that organic compounds can be formed below sedimentary rocks, while Claus and Nady assume the appearance of life at the depth of the mantle. Morrison [1962] adds a correction to the conclusions of Claus and Nady. He showed that these investigators took skeletons of crystals - carbonaceous "snowflakes" as the "organized elements".

Now it remains to show a genetic connection between compounds of carbon and metal carbides. In other words, we must show that iron carbide is the parent matter of all carbon compounds in the mantle.

There are direct indications that iron carbide (cementite) undergoes hydrolysis. Methane, ethane, ethylene, hydrogen, liquid and solid hydrocarbons and graphite are products of this reaction [Tropsch, 1952]. During the hydrolysis of iron carbide, if gaseous hydrocarbons alone appear we would then have reason to supplement them with liquid and solid polymers, the formation of which under conditions of the upper mantle is completely probable. However, the properties of cementite appear during hydrolysis with such a variety of products obtained from it that there is no need to add anything.

Under the conditions existing in the mantle, in contrast to the conditions of laboratory experiments on the hydrolysis of cementite, nitrides and metal sulfides are hydrolyzed at the same time. In the products of such non-isolated reactions, not only are hydro-

carbons observed but also the hydrocarbon derivatives, oxygen, nitrogen and sulfur. We must assume that hydrogen sulfide and ammonia, as well as sulfur and nitrogen, are the primary hydrolytic products from sulfides and nitrides.

Nash and Bakker [1961] established the mean nitrogen content in eight iron meteorites as equal to $0.5 \text{ mm}^3/\text{g}$. Cohen [1894] summarized the gas analysis of meteorites; they show a nitrogen content of about 5% of the total sum of gas components. Cloez [1864] established 0.1% ammonia in the meteorite Orgueil. The discovery of a rare mineral -- osbornite (titanium nitride) in an achondrite is very interesting. Carbonaceous chondrites also contain free sulfur. /66

If the hydrolytic processes of metal carbides in the reaction zone of the upper mantle occurred singly, we would then be correct in expecting only the formation of hydrocarbons. However, in the reaction zone, hydrolytic processes of the nitrides, sulfides, etc., take place along with hydrolysis of the carbides. The ammonia, hydrogen sulfide and carbon dioxide created during these processes become participants in the process of forming naphthenic acids, pyridine, quinoline, thiophene and their derivatives.

In discussing the question of the formation of hydrocarbons and their derivatives, it is quite appropriate to cite the position taken by Vernadskiy [1960]: "It is necessary, above all, to emphasize here that petroleum can not be thought of only as hydrocarbons. Hydrocarbons only prevail in their composition. They always contain many percents, sometimes tens of percents, of compounds which include oxygen, nitrogen and sulfur. To explain their genesis only by the origin of the hydrocarbons is wrong. This is often forgotten".

On the whole, the deep-seated processes with respect to mass of the reacting materials, and differences in direction are quite large. The directions of water and petroleum formation are not involved to any great degree and are observable only because they can be collected and extracted from the solid rocks. Under the conditions existing in the third reaction zone of the Earth it is probable that neither the gases nor the vapors have been liberated. They represent the total system of gases and vapors dissolved in the magma. Under the conditions existing in the crust, with the changed pressure and temperature, a conversion to the system solution - emulsion - suspension occurs. The further decomposition of this system is accompanied by precipitation of the solid phase, by condensation and stratification of the liquid phase, and by liberation of the gaseous phase. All the sediments remaining, as the deep-seated matter travels upward toward the upper boundary of the Earth's crust, may be assumed to be sediments from the water and petroleum, which travel with them from the interior of the Earth. /67

This mechanism involved in the process of petroleum production

is not due to any special structure. It follows naturally from the nature of the planet itself. This mechanism includes earlier views concerning the mineral origin of petroleum: the carbide hypothesis of Mendeleev and the magma hypothesis of Kudryavtsev [1956].

The theory of a mineral origin of petroleum, unlike the theory of an organic origin, gives more valid answers to the many questions concerning petroleum. The question of time and place of petroleum formation, from the viewpoint of organic theory, is related to sedimentary rocks. From the viewpoint of mineral theory, the appearance of petroleum is due to internal activity in the planet. Petroleum has been formed in the past in the upper mantle of the Earth, is constantly forming now, and will be formed in the future as long as the internal activity of the planet continues. Carbides of metals, primarily iron carbides, are the parent matter of petroleum. In the lower mantle, carbon is still found in the form of metal carbides, but in the upper mantle and in the waveguide zone, metal carbides undergo hydrolysis and carbon changes form and is disproportionated.

No matter where petroleum is found on the Earth's surface, in rocks and zones remote from sedimentary rocks or, finally, in sedimentary rocks themselves, none of these are where petroleum was formed, but rather places to which the carbon migrated. Petroleum enters the crust at the common growth base of the crust as a result of differentiation of matter in the mantle.

Organic theory can not completely explain the entire chemical composition of petroleum and its associated minerals as well as it should. The complete chemical composition of petroleum, the ratio of petroleum to water, the chemical composition of drilling fluids and the mineral deposits in petroleum beds must all be studied in the closest relationship. All the associated minerals of petroleum are components of this complex mixture, which is created along with the petroleum.

The results given by Beskrovnyy are in agreement with this, in that he reports a widespread development of petroleum bitumens and hydrocarbon gases in volcanic tubes embedded among the different rocks under various geological conditions as well as in crystalline rocks that are quite remote from normal sedimentary rocks. Under such conditions bitumens are encountered in association with hydrothermal postmagmatic minerals and strongly mineralized waters. On the basis of primary inclusions of bitumens and hydrocarbon gases existing in the hydrothermal minerals, the author concludes, correctly in our opinion, that a true paragenetic relationship exists between them. The existence of such a relationship makes quite probable and logical his further conclusion that a single source is responsible for the hydrothermal solutions of kimberlite tubes, petroleum bitumens and hydrocarbon gases.

/68

Petersil'ye, Andreyeva and Sveshnikova, in their book "Organ-

icheskiye veshchestva v gornyykh porodakh nekotorykh shchelochnykh massivov Sibiri" (Organic Materials in Rocks of Several Alkali Massifs in Siberia) [1965] also concluded that the hydrocarbon gases and bitumens, which are confined to massifs of nephelinic syenites, are also of mineral origin. These authors see the possibility that hydrocarbons have formed in the syenites themselves, where carbon and carbon monoxides are deoxidized by hydrogen or water due to the participation of natural hydrogenating catalysts, rather than in the mantle. Here they have ignored the question of the origin of carbon and carbon monoxides.

Earlier it was shown that the hydrolysis of metal carbides occurs in the waveguide of the mantle and, depending on the conditions, it can take either a carbon dioxide or a hydrocarbon direction. In this light there is not the slightest need for any additional superstruction in the form of reducing carbon oxides to hydrocarbons. This is even further cause for the assumption in the overall plan of reducing carbon monoxides to hydrocarbons to have excluded the appearance of this latter in the rocks. Elementary carbon and carbon monoxides by their presence in rocks of the crust testify to the fact that they have not been reduced to hydrocarbons there. If the assumption of such a reduction requires proof that hydrocarbons can not be formed in the mantle, it is then futile to attempt to do so. We must not forget that the high temperature in the upper mantle is accompanied by high pressures, and if the high temperature tends to produce dissociation of the organic molecules, the high pressure will prevent it. Carbonaceous chondrites are proof of this. They include significant amounts of different hydrocarbons and their derivatives. /69

In addition to the above, the formation of hydrocarbon gases and bitumens from carbon and carbon monoxides is still improbable since we have assumed an inadmissibly high concentration of carbon monoxides and hydrogen in the rock pores and an inadmissibly high probability that hydrogen will react with graphite. It is doubtful whether rocks of the Khibini Massif could contain such an amount of carbon monoxides and hydrogen in their pores that could be equivalent to the Khibini hydrocarbon gases and bitumens.

Now let us touch upon the problem of petroleum and natural gas reserves in the Earth's crust. The problem of estimating petroleum reserves in the Earth is always a complex one. The numerous predictions in the past have never been confirmed. Russell's prediction [1958], according to which the petroleum reserves in the Earth amount to $6.75 \cdot 10^{10}$ T, has likewise not been proven. If we consider that more than 1 billion T of petroleum were extracted in 1960, and that every 20 years it increases 5 times, we must then assume (according to Russell) that by 1980 all the petroleum will have been pumped from the Earth. Even at the present time this prediction does not correspond to available information on the discovery of large new petroleum deposits.

Our estimation of the petroleum and natural gas reserves in the Earth's crust is based on the following calculations. The mean carbon content in the matter of the upper mantle is 0.33%. If the carbon content in the Earth's crust corresponded to that in the upper mantle then with a total mass of the crust of $3 \cdot 10^{25}$ g there would be a minimum of 10^{23} g carbon in it. The hydrocarbons, which in final analysis, are converted to carbon dioxide are the predominant form of carbon on the surface of the planet. According to Poldervart [1957] the carbon dioxide content in the Earth's crust is estimated at $250 \cdot 10^{15}$ T. In converting to carbon this amounts to $0.68 \cdot 10^{23}$ g. Hence it seems that there must be an additional $0.32 \cdot 10^{23}$ g of carbon in the form of hydrocarbons in the interior of the Earth's crust. These reserves of carbon in the crust can be subdivided into petroleum, natural gases and graphite. According to Fersman [1953] the weight ratio of natural gas to petroleum is assumed to be 1:2. In this case the reserves of carbon are expressed in the following way: $0.1 \cdot 10^{23}$ g in the form of natural gas; $0.2 \cdot 10^{23}$ g in the form of petroleum; and $0.2 \cdot 10^{23}$ g in the form of graphite. This figure for the petroleum reserves exceeds Russel's prediction by a factor of 10^6 . /70

The reserves of natural gas and petroleum in the Earth's crust do not remain constant, not only because there is a constant expenditure of petroleum, but because petroleum is constantly being replenished as a result of migration from the mantle.

From this discussion on the origin of petroleum, it follows that the process of petroleum formation is a *planetary one*, beginning from the deep-seated parent matter, iron carbide. The other planetary process, the formation of life, also begins from iron carbide and occurs in parallel and independently of the first (see below). These two independent directions do not intersect and do not depend on one another for their origin. One of them occurs by intrusion in the hydrocarbon direction, and the other volcanically in the carbon dioxide direction. There is no third direction (the formation of petroleum from organic compounds) in the planet and there is no place for organic theory in explaining the origin of petroleum.

The problem involved in the origin of diamonds is closely related to that of petroleum. Compounds of carbon, graphite and diamond are only variations in forms of carbon. They are created under planetary conditions from the same parent matter (iron carbide), by the same reaction (hydrolysis) and in the same stratum of the mantle (the waveguide). Here it is very interesting to note that both directions of iron carbide hydrolysis (hydrocarbon and carbon dioxide) are accompanied by the formation of graphite.

The discovery of graphite in the composition of meteorites confirms that hydrolytic processes are accompanied by the formation of graphite in the waveguide. However, if we bear in mind that the pressures reach 100,000 atm in the waveguide, and that the tempera-

tures reach 2400° C [Kryatov, 1966], under these conditions, we can not eliminate the possibility of an allotropic form of carbon (diamond) along with the formation of graphite. It is not merely by accident that diamonds are also found in the composition of certain meteorites. In whatever aspect we might examine the problem in-

involved in the origin of diamonds we can only conclude that they are /71 of *mineral origin*.

However, several opinions have been expressed about the organic origin of diamonds. Kryatov [1966], in his article "Diamonds of Yakutsk", cites the hypothesis of a group of geologists from the Yakutsk Division of the USSR Academy of Sciences about their organic origin. In their opinion the basaltic magma in its rise to the Earth's surface is enriched with alkalis, in particular, nickel. As a result, a favorable chemical medium is created for the formation of diamonds. The thermodynamic conditions are created due to capture of the gases by magma and to their reaction. These explosive reactions would seem to be accompanied by the liberation of carbon and an elevation in temperature and pressure. They cite as proof the distribution of kimberlite tubes within the petroleum and gas structure, or along with it.

Such a hypothesis for the origin of diamonds is unacceptable to us. In the first place, there is no need to create a chemical medium in the crust if it exists in its best variation (in the waveguide). In the second place, it is entirely improbable that such a concentration of gases from carbon compounds was created where several hundred grams of diamond crystals could be formed. In the third place, the distribution of kimberlite tubes within the petroleum and gas structure is proof that diamonds and petroleum are formed simultaneously in the same zone.

Thus we conclude our study involving problems in the differentiation of products forming during the time of deep-seated chemical processes in the interior. The differentiation of planetary matter, beginning at its core and ending at its boundary with space, probably is the most characteristic feature of the Earth. The motive force of this process is not merely, nor even so much, gravitation, as it is how constantly are the temperature gradients maintained in the three reaction strata of the Earth. The planet is an *extraordinarily complex thermodynamic system*, in which not one component of the planetary matter remains in a constant state or at a constant depth.

THE EARTH'S CRUST

The Earth's crust which was produced by the mantle as a result of the differentiation of matter constantly replenished itself and is replenishing itself at the present time. It will continue to replenish itself in the future as a result of the unceasing supply of deep-seated matter. In the early stage of the Earth's internal activity there was not enough differentiation of the matter to cause the formation of such a large crust stratum. Only with the further differentiation of the planetary matter did the Earth's crust gradually begin to build up. If we assume that the formation of the crust began 3 billion years ago, then the modern crust of $3 \cdot 10^{25}$ g was built up by the addition of 10 billion Tons of matter per year. The mantle pushed about 2% of its mass to the surface. /72

Both the process (which we shall call intrusion) of quiet penetration of the deep-seated matter through the boundary of the mantle and the volcanic process (the eruptive surge of deep-seated matter through the boundary of the mantle and crust) participated in the formation of the crust. There is also an intermediate variant when the volcanic products of an insufficiently powerful source do not reach the upper boundary of the mantle or the upper boundary of the crust. Any further upward penetration of these volcanic products becomes possible only by intrusion.

The encrustation products are easily distinguished from other fluid products by the composition of the gases. A high content of hydrocarbons, methane in particular, is characteristic of gases accompanying intrusion, and nitrogen can be found in the form of ammonia. For volcanic gases a high content of carbon dioxide is characteristic, while nitrogen in such case is found in elementary form, rather than in the form of ammonia.

According to Kropotkin [1959], prior to the Cambrian period, $3 \cdot 10^{22}$ cm³ of lava were erupted, which amounts to hundredths or thousandths of a percent of the total mass of the Earth's crust. /73 Therefore, the Earth's crust with respect to its origin is, on the whole, intrusive rather than volcanic. The difference between the intrusive means of forming the crust and the volcanic means lies in the gradual process of cooling, crystallization and evaporation. However, considering that the source of intrusive and volcanic matter is the same (the third reaction zone of the Earth), in their solid state they can not be sharply distinguished. Comparison

among the compositions of volcanic rocks, crust and tektites given earlier testifies to this. The similarity among the indicated compositions is obvious.

TABLE 23

Elements	Mean Composition wt. %		Ratio II / I
	Outer Zone of the Earth up to 1000 km	Lithosphere to a Depth of 16 km	
	I	II	
Si	22,2	26,0	1,2
Al	5,35	7,4	1,4
Mg	9,96	2,3	0,2
Na	1,88	2,4	1,7
K	1,33	2,3	1,7
Ca	3,43	3,2	0,9
Fe	5,87	4,2	0,7
Ti	0,39	0,6	1,5
Mn	0,03	0,1	3,5
H	4,0	1,0	0,2
C	0,32	0,35	1,1
N	0,13	0,04	0,3
P	0,15	0,12	0,8
S	0,58	0,1	0,2
O	43,97	49,1	1,1

A high content of compounds which possess a high rate of migration from the interior of the planet to its surface is characteristic of the source of the Earth's crust and the crust itself. We can get some idea of the migration rate of individual components of the deep-seated matter by comparing the compositions of the outer zone of the Earth at a depth of 1,000 km (according to the author) and the lithosphere at a depth of 16 km, including the atmosphere and the hydrosphere (according to Fersman). Such a comparison is given in Table 23.

From the above comparison of the compositions of the upper mantle and the lithosphere it follows that the Earth's lithosphere is enriched at the expense of the mantle by silicon, aluminum, oxygen, sodium, potassium, titanium and manganese. Compounds of these elements possess an increased rate of migration. However, this is not observed in the ratio of the compositions of magnesium, nitrogen, phosphorous, sulfur and iron. There is a higher content of these in the mantle than in the lithosphere. /74

The results of the comparison were quite unexpected. Apparently, the migration rate of the compounds from the interior of the planet to its core is determined not by their molecular weight nor even so much by their solubility as by their fusibility. We can easily see this by comparing the melting points of different silicates (Table 24).

TABLE 24

Salts	$T_{\text{melt}}^{\circ}\text{C}$
K_2SiO_3	976
Na_2SiO_3	1089
CaSiO_3	1540
FeSiO_3	1550
MgSiO_3	1557
$\text{Al}_2\text{O}_3 \cdot \text{SiO}_2$	1860
H_2SiO_3	2200
	volatilization

The difference in melting temperature of silicates of alkali metals and silicates of calcium, magnesium, iron and aluminum can not affect the differentiation of matter during zone melting in the mantle and the gradual crystallization during cooling in the crust.

If the migration rate of compounds is determined by their fusibility, the question arises: why are such low-melting compounds as ammonia, phosphine, hydrogen sulfide and certain other volatile compounds not found in the lithosphere in a significantly higher concentration?

Finally, why does a volatile compound such as water not migrate to a larger extent to the lithosphere? The answers to these questions must, in our opinion, be the following. It is understood that volatile compounds possess an increased migration rate, and if their concentration does not correspond to their migration rate, then it is not a matter of their migration rate that is involved. The essence of the phenomenon consists of the formation rates of volatile compounds in the waveguide. Formation rates, in turn, are limited by the migration rate of the nitrides, sulfides and phosphides, from the deep-seated strata to the waveguide. As a result, apparently, the migration rate of volatile gases is limited by the migration rate of the nitrides, sulfides, phosphides, etc. The high melting points of these compounds do not permit them to develop a high migration rate to the waveguide.

Now let us concern ourselves with the problem of the migration of water. In contrast to the volatile compounds just examined, water seems to possess a high migration rate. Its mean content in the outer stratum of the Earth is 3.0%, and in the crust, 5.5%. It is understood that here the problem is not that water has a higher migration rate than gases, but that water is formed in the waveguide at greater rates than gases. Water is supplied to the waveguide from the interior in the form of fusible acid silicates of alkaline salts or in the form of volatile hydrides of alkali metals [Shchukarev, 1965]. Both acid silicates of alkali metals and hydrides of alkali metals dehydrate under waveguide conditions. The yield of free

water in the waveguide is determined by the ratios of this reaction. The migration of water from the waveguide to the crust is determined by its own migration rate.

A rise in the concentration of oxygen in the lithosphere by 1.13 times in comparison with its content in the upper mantle is explained by the fact that in the lithosphere, oxygen-enriched compounds have been concentrated (silicon dioxide, water and aluminum oxide).

From comparison of the compositions of the matter in the mantle and the lithosphere a sharp divergence results in the concentrations of hydrogen. In the upper mantle it could be 4.0%, while in the lithosphere only 1%. Probably such a divergence can hardly be explained by the small migration rate of hydrogen. It seems that for hydrogen there are no limiting circumstances to its migration from the core of the Earth to space.

Hydrogen, in contrast to other light elements, is not connected with the solid phase as are the former. Therefore, the ratio of volatile to nonvolatile components of magma is least of all determined by the presence of hydrogen in the volatile fraction. In Table 25 a calculation of the content (in wt. %) of volatile compounds with respect to each other and with respect to the solid fraction is given.

If we assume that all the light metals form volatile compounds, then their total amount in the mantle may be 4.18%. Since with migration to the lithosphere the ratio of volatile to nonvolatile is destroyed by the different migration rate of the separate components, it is necessary to calculate this ratio. The transfer coefficients given in Table 23 for the separate materials from the mantle to the lithosphere make it possible to establish that the new content of volatile materials in the lithosphere is not 4.18% but 6.1%. This growth occurred mainly due to the almost doubled amount of water in the lithosphere as compared to the amount in the mantle. /76

TABLE 25

Volatile Elements and Compounds	Upper Mantle		Lithosphere	
	to Weight of the Upper Mantle	In Gas Vapor Fraction	to Weight of the Lithosphere	In Gas Vapor Fraction
H ₂ O	3,0	71,7	5,5	90,0
S	0,6	14,2	0,10	1,6
C	0,34	8,1	0,35	6,0
P	0,1	2,5	0,12	1,8
N	0,14	3,5	0,04	0,6
Total	4,18	100,0	6,11	100,0

The ratio of the components of the gaseous phase is: nitrogen - 1; sulfur - 2; phosphorous - 3; carbon - 10; and water - 150 parts by weight. In light of this, it is interesting to cite data from the experimental observations of S. I. Naboko [1959] in determining the volatile compounds during a volcanic eruption in Bilyukay in 1947. The total amount of volatile compounds was estimated by her at 2%. Naboko correctly notes that the volume of volatile compounds is great, whereas they have a small percent by weight. Also the remark that water is the main volatile product is correct.

It is probably more reliable to judge the ratio of volatile compounds and the solid phase during the migration of the deep-seated matter to the surface of the planet on the basis of the weight ratios of the lithosphere, atmosphere and hydrosphere. If we take only one component of the volatile phase, water, it then amounts to 5.5% of the entire mass of the crust. Therefore, the ratio of all volatile compounds to the solid phase must be greater than 5.5%.

Earlier it was said that by whatever paths the deep-seated matter enters the Earth's crust it remains the same. The way the deep-seated matter enters the crust affects only the mechanism of the decomposition of that system represented by magma under conditions of the mantle. /77

The deep-seated matter at the source of a volcano may represent a single dispersed system with dissolved gases and vapors in the melt of solid matter. This system, under conditions of rapidly decreasing temperatures and pressures, also is rapidly decomposed into gases, vapors and a melt with subsequent crystallization, condensation and evaporation of the eruption products. We can imagine how that same system of deep-seated matter decomposes if it penetrates the crust in the form of intrusions. In this case, the decomposition mechanism of deep-seated matter exists under conditions of a gradual drop in temperatures and pressures. On the migration path of the matter, very slow graduated processes of crystallization, condensation and evaporation occur. At first it is primarily the refractory silicates of magnesium, calcium, iron and aluminum that begin to crystallize, and then the less refractory silicates of alkali metals. As a result of such a stage in the decomposition and cooling, differentiation of the material first forms saturated and then increasingly less-saturated solutions. These solutions are called salts which, depending on the stage of differentiation, have different concentrations of soluble matter. Sometimes salts, whose concentration reaches 600 g/liter, are found. The processes of ion exchange and hydrolysis which take place in the salts lead to the precipitation of low soluble salts, and, therefore, to a decrease in the concentrations of solutions. The migration of solutions to the zones of decreased pressures is accompanied by the separation of dissolved gases in them.

Thus, such observable phenomena in the crust as the formation of mineral deposits, the system of aqueous solutions, receptacles with petroleum and receptacles with gases are simply separate parts of the differentiation of deep-seated matter entering the crust.

The increase in mineralization of solutions with depth, the decrease of sulfation and quantities of the proportions Na/Cl and Cl/Br, the combination of desulfurized waters with light petroleums and, conversely, the combination of sulfurized waters with heavy petroleums, etc., which have been cited in this group of rules, often have an entirely incorrect interpretation.

The increase in the mineralization of salts with depth testifies neither to the appearance of gravitational forces nor to the increased dissolving of the Earth's rocks by surface water. These are deep solutions whose role is not to dissolve the rocks of the crust but, on the contrary, to form them by precipitating materials from the solutions. /78

The decrease in sulfation with depth can occur because deep bivalent sulfur is oxidized either as a result of radiogenic oxygen or as a result of atmospheric oxygen in the upper strata of the crust.

The combination of desulfurized waters with light petroleums and, conversely, the combination of sulfate waters with heavy petroleums correspond to the fact that, in the stratification zone of petroleums and waters, in which the oxidation of bivalent sulfur to sulfates is possible, the oxidation of petroleum with its conversion from light to heavy petroleum also takes place. In those zones where the oxidation of sulfur with the formation of sulfates is excluded, the oxidation of light petroleum with its conversion to heavy petroleum is also excluded.

At this stage of our work everything which has been said leads us to pose the questions about the structure of the Earth's crust.

Let us trace the change in the Earth's crust historically. The young Earth at the beginning of its internal activity may have had a surface free from any structural neogenesis. Moreover, at this time the Earth, in general, did not have a crust. In proportion to the development of the internal activity the differentiation of the planetary matter caused by this gave rise to the formation of a layer of plastic material (the waveguide). Simultaneously with the formation of the waveguide the process of the flattening of the Earth began. The change from the ellipsoidal shape to the modern shape may have been accompanied by flattening primarily along the major axis of the ellipsoid. According to calculations given earlier, the axis may have contracted by 1800 km in this direction. This means that more than anything the plastic material located in the equatorial zones of the waveguide was subjected to pressure.

Here conditions were created under which there occurred a constant efflux of plastic waveguide material from the equatorial zone to the polar zones. As a result, the thickness of the waveguide in the polar zones increased. This was reflected in the structure of the planetary surface: along the equator there arose primary depressions, and along the polar zones primary elevations equivalent to them. /79

The scope of the entire planetary surface caused not only by the forces of the Earth's flattening but by the maximum forces of the waveguide flattening in the equatorial zones as a result of the maximum rate of the rotation of the ellipsoidal Earth is characteristic of the primary structural formations of the Earth's crust. Later, with the decrease in the rate of rotation of the Earth, the pressure on the equatorial zones of the waveguide decreased. With respect to this, the redistribution of the plastic waveguide material took place only in the bounds of the equatorial zones. In one region of the equatorial depression there occurred a secondary deepening, and in the other region of this same depression there occurred a secondary equivalent elevation. These secondary changes in the waveguide were expressed in the structure of the Earth's crust in the form of deep oceanic depressions and oceanic ridges. Oceanic ridges, by their distribution and extent, confirm the concept that their origin was connected with the Earth's rotation.

The plastic material of the waveguide, by its redistribution in a horizontal direction, created the structure of the Earth's crust, and by its shift to the surface and the eruptions on it influenced the growth of the Earth's crust. With the deformed structure of the waveguide the regular entry of the deep-seated matter to the entire surface of the crust was excluded. One of the reasons for the rapid growth of the crust in some regions and the slow growth in other directions is its proximity to or distance from the waveguide.

In proportion to the progress of the deep-seated matter to the upper boundaries first of the mantle and then the crust, this matter was found to be under constantly changing conditions of temperature and pressure. With the gradual cooling of the deep-seated matter, prerequisites were created for further differentiation. At first the refractory materials (silicates of magnesium, calcium and iron) were crystallized, then silicates of aluminum, and even later, silicates of alkali metals. Such a differentiation of matter coming from the mantle leads to formation of the basaltic and granitic strata of the crust.

With a thin and deeply-seated waveguide the crust developed as a depression at slow rates of growth. The oceanic crust can serve as an illustration of this. The thickness of the oceanic crust is 5-6 km; whereas the continental crust under the Caucasus, Pamirs, and Andes reaches 60-80 km. In contrast to the continental crust, the oceanic crust consists of one basaltic stratum. The small /80

growth of the crust in the deep depressions is explained, evidently, by the comparatively small amount of deep-seated matter which entered. The fact that the oceanic crust is basaltic can testify to the differentiation of the waveguide matter in a horizontal direction. In the higher distributed waveguide zones are found the most active part of the matter which supplies the crust not only during formation of the basaltic stratum but also during formation of the granitic stratum.

If we can find common features between such extremes as the deep depressions and the high elevations, then there must be even more in common between two depressions or two elevations. Thus for example, with the given distinction between a platform and a geosyncline, there do exist common features. In light of this fact, Karpinskiy is correct when he says that the platform crust is not an inert rigid block.

The structural changes in the Earth's crust due to the build-up of its mass are minute architectural features on an overall background of primary structural formations. When a certain height is reached for an elevation, the mass of the built-up crust begins to exert pressure on the waveguide, as a result of which any further migration of the deep-seated matter in this zone of the crust ceases. The migrating streams take on a new direction--into those contiguous zones where the pressure on the waveguide has a minimum value.

The processes of nonuniform growth of the crust, with respect to its different zones, take place with the constant interruption of the gravitational field. Accordingly, we must assume Gutenberg [1949] to be correct when he says: "It is impossible to assume any tectonic hypothesis which would not correspond to observed anomalies in the force of gravity."

According to the calculations given by us for one of the variants, the total surface of the young Earth was 651 million km^2 . The area of the modern Earth is estimated at 510 million km^2 . This means that, as a result of the flattening of the Earth, its surface contracted by 141 million km^2 . Since the depressions of the crust are equivalent to the elevations, the areas of the depressions and elevations are each equal to 70.5 million km^2 . This condition is confirmed quite well by the curves constructed by Zupan and Lapparan depicting the relief of dry land and the depth of the sea. Here reverse curves are plotted that are similar in geometrical shape and dimensions. With respect to these empirical generalizations, V. I. Vernadskiy [1965] notes: "This is not random accuracy . . . there is not one satisfactory scientific hypothesis for this empirical generalization, but nevertheless the conclusions which we must make from this are of first-rate significance." /81

In order to cause such huge changes, powerful forces strictly

directed in time and space must occur not only in the crust but in the whole body of the planet. The planet has such forces. They begin at a great depth in the planet. The deep chemical processes of decomposition of the primary planetary matter give rise to a decrease in the planetary volume and a very powerful shift of matter in the whole planet. If to these processes we add processes due to the change in the planet's shape and to the change in its rotation rate, then we obtain a synthetic phenomenon called *tectogenesis of the Earth's crust*.

Tectogenesis of the Earth's crust will continue to the end of its existence and may be the cause of its eventual destruction. By the time the Earth's internal activity is extinguished its radius will have contracted by 470 km, while the surface of the crust will have diminished by 72 million km². At the present time in the Earth there are stresses due to the nonuniform cooling of its various strata. The bonding forces will weaken, the planet will be destroyed and will cease to exist.

The concepts presented here concerning the structure of the Earth's crust have points in common with other existing hypotheses. At first glance it seems that the concept set forth here is closest to the contraction hypothesis. However, we soon see that this is not the case by a very close examination and a comparison of concepts. The essence of the contraction hypothesis is as follows. It assumes a "liquid" state of the Earth in the past. With the passage of time the mantle of the Earth cooled and hardened, and its internal zones are still continuing to cool and contract. Under these conditions, the crust becomes amply large for the core. It sags and collapses into folds as a result of the horizontal contractions.

That which forms the basis of the contraction hypothesis not /82 only disagrees with our concept, but is diametrically opposed. The existence in the past of a "liquid" Earth, assumed by contraction hypothesis, does not agree with our concept of the origin of the Earth. Earlier we said that the Earth was never in a "liquid" state, but that nevertheless a large part of its material gradually went through a stage of melting in the reaction zones. Such a passing of the Earth's rocks through a melted state is not proof of the existence of a "liquid" Earth in the past.

Further, contraction hypothesis assumes the possibility of a cooling of the "liquid" Earth. In our concept such a form of cooling for the modern Earth is excluded. The Earth is found in a state of internal activity which can continue on the order of 1 billion years if the Earth is not subjected to external destructive forces before that time. If we nevertheless assume the possibility of the contraction of the crust during cooling, then the forces arising here are too small to cause the actually observable changes in the Earth's crust. According to our calculations, the total contraction

of the Earth's crust is 141 million km². This figure is far from that given by the contraction hypothesis, but is very close to the value obtained in calculating the area of the Earth's elevations and depressions.

V. V. Belousov [1962] subjected the contraction hypothesis to a shattering criticism. He notes that in the contraction hypothesis nothing is said about the formation of continents and oceans. According to this hypothesis, we would have to expect destruction of the platforms by the forces of contraction and the breaking away of the Earth's crust from the core. In examining the problems of the genesis of folding, Belousov came to the conclusion that all forms of folding are in one way or another the result of vertical shifts in the Earth's crust. On this basis the conclusion is made that the contraction hypothesis was lacking in one important area--an explanation of folding. In this case it is appropriate to recall the words of Vernadskiy: "The history of these concepts shows that all these hypotheses and all the concepts connected with them are too simple and that the natural phenomenon is more complex."

THE EARTH'S HYDROSPHERE

The hydrosphere does not appear on the Earth in a finished form from without. The primary planetary matter is the source of water on the planet. It accumulates hydrogen in the form of hydrides of metals, and oxygen in the form of peroxides of metals. During the internal activity of the Earth with the decomposition of peroxides and hydrides of metals an amount of water equal to almost 32 Pacific Oceans may have been created in the first reaction zone. We may assume that this entire amount of water is directly bound chemically with the oxides of alkali and alkali earth metals being formed and, possibly, with silicon dioxide with the formation of hydroxides and disilicates. If we convert the yield of deep-seated water with respect to the total mass of the upper mantle where it ultimately arrives, it then amounts to 3%. We must not fear a universal flood on the Earth because the water in the body of the planet remains in a chemically bound state and, in addition, a significant amount of deep-seated water is expended in the hydrolytic processes. After the complete hydrolytic processes in the mantle, water comprises only 7.71% of the mass of the upper mantle instead of 3% (Table 16). This figure for the water content in the mantle is extremely probable if we bear in mind that the mean water content in meteorites is estimated to be 0.5%.

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The distribution of chemically bound water throughout the thickness of the mantle is *nonuniform*. The sublimation and melting of hydroxides and silicates of alkali metals impart an increased migration rate to the chemically bound water. As a result, in the upper layers of the upper mantle, in the Earth's crust, and finally, in open reservoirs of the Earth, water is accumulated. The Earth's hydrosphere with respect to the mass of the crust amounts to 5.5%.

The mass of the modern Earth's hydrosphere is the result of a constantly operating system on the Earth of development and expenditure of water. On one hand, the deep-seated water constantly enters the Earth's surface; on the other hand, the water from the surface reservoirs is continually being expended. A slight delay between expenditure of water on the Earth and its arrival led to the formation of a hydrosphere.

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The modern mass of the Earth's hydrosphere can never be assumed as a planetary constant. The mass of the hydrosphere is a function

of the internal activity of the Earth and the temperature conditions on the surface of the planet. Neither this nor any other condition remains constant.

TABLE 26

Crust Reducing Agent	Expenditure of Oxygen, 10^{23} g
C	1.82
N	0.2
P	0.35
S	0.10
Fe*	0.85
O ₂ **	0.01
Total.	3.33

Note: * O₂ content in the air.

** Bivalent iron.

In the future the Earth is still capable of producing water in the amount of 18 Pacific Oceans. With the passage of time and with a drop in the internal activity of the Earth, the development of water will not be able to compensate its expenditure and as a result the mass of the hydrosphere will decrease.

The uncompensated expenditure of water will lead finally to disappearance of the hydrosphere. The hydrosphere was created and will disappear at definite stages in the Earth's development.

With the evaporation of water from the Earth's reservoirs in the amount of 0.22 of the Pacific Ocean and its subsequent dissociation in the atmosphere, $3.3 \cdot 10^{23}$ g of free oxygen may accumulate. However, it is known that, in the atmosphere of the modern Earth, oxygen amounts to 10^{21} g. This difference might have been expended on oxidation of the Earth's crust. In the Earth's crust, according to A. Poldervart [1957] there exists (in 10^{15} t): Fe₂O₃ - 661; P₂O₅ - 62; CO₂ - 250; nitrogen 6 - 8; and sulfur 4 - 7. All these elements, with the exception of iron, may be created in the form of hydrides, while iron may be found in the form of an oxide. Under conditions of the crust these elements have been subjected to oxidation. The expenditure of oxygen on the oxidation of these reducing agents in the crust may be expressed in the amount of $3.33 \cdot 10^{23}$ g based on the calculation given in Table 26.

The expenditure of atmospheric water during dissociation is calculated on the basis of the expenditure of oxygen. It amounts to $3.74 \cdot 10^{23}$ g or 0.22 of the Pacific Ocean. /85

E. K. Byutner [1959], in his work on the photodissociation of

atmospheric water, notes that the magnitude of the oxidation rate of the Earth's crust is of the same order as the liberation rate of molecular oxygen with the photodecomposition of water.

There is a rather wide range of current views on the origin of water. Even though these views all accept the existence of deep-seated waters, such questions as the specific sources of water and the specific depths of their distribution remain unanswered. The acceptance of deep-seated water with an extraplanetary formation, as well as the assumption that water exists only at comparatively shallow depths, are views which do not coincide at all with our concept concerning the origin of the Earth's hydrosphere.

According to some theories the total mass of the hydrosphere is increasing and the ocean is encroaching onto dry land. However, it is unknown where that water source is located on the Earth from which the Pacific Ocean extracts its water. Perhaps these are the sources discovered by V. F. Derpgol'ts [1962], i.e., water from the lithosphere, meteorites, ice cores of comets, or from the oxygen and hydrogen in solar rays? With respect to these sources we could say that the sources of water are many but that the amount is small! Furthermore, we can not see how meteorites and comets were included in the group of primary water sources when they themselves are planetary fragments.

The fact that the true source of water on Earth remains unknown leaves a number of gaps in the natural sciences, in particular in the field of hydrogeology. The following questions are of concern here: the detection of waters with an extraordinarily high degree of mineralization; the location of the concentrated salts not coming in contact with salt rocks; the assumption that waters containing organic compounds are the parent matter of petroleum; the detection of deep hydrochemical anomalies; the discovery of sharp differences in pressure in contiguous strata; the existence of petroleum deposits with high pressures; the alternation of oil-bearing and water-bearing levels and the vertical migration of water, petroleum, etc.

Out of the numerous hypotheses there are those which approach /86 the true state of affairs. Included here, in our opinion, are the explanations given by Krotova and other hydrogeologists for phenomena which they observed. The large number of deep-seated hydrochemical anomalies which appear in the Volga-Ural petroleum-gas region have been properly explained by Krotova as due to the discharge sources of subterranean waters confined in this area. We also feel that Krotova [1962] is correct in attributing the formation of chloride calcium - sodium salts to magmatogenous waters.

Everything that is observed separately in the field of hydrogeology is simply a part of the same overall picture which represents the unyielding advance of deep-seated water with its changing

associate minerals, beginning from the boundary of the Earth's crust and ending with the boundary of the atmosphere with space.

For matter of such a small weight, water has played a huge role in the development of the planet. It participates in the reduction-oxidation processes, in the hydrolytic processes, and processes of lixiviation, differentiation and transport of the planetary matter. Water influences the structure of the outermost stratum of the Earth's crust, and to a large extent determines the climate of the planet. It participates in the processes of regeneration of the atmosphere, by yielding molecular oxygen and absorbing carbon dioxide. Later it will be shown that only when water becomes a component part of the atmosphere can habitation appear on a planet. Indeed, the role of water in the development of the planet is difficult to exaggerate. V. I. Vernadskiy [1960] estimates the role of water in light of its omnipresence. He says: "... In the Earth's crust its role has invariably been exceptional in the course of almost all, if not all, geological time. This geological fact is of paramount importance."

THE EARTH'S ATMOSPHERE

The gas mantle of the Earth (the Earth's atmosphere) could be formed only as a result of the continuous entry of subterranean gases. Therefore, *the primary atmosphere* of the Earth may have consisted of methane, ammonia, carbon dioxide, nitrogen, etc. If all the deep gases entering the atmosphere were retained in it, then at the present time the mass of the atmosphere would be significantly larger. There are no reasons for assuming that all the gases formed in the deep-seated chemical reactions entered the atmosphere. Also, there are no reasons for assuming that all the gases which entered the atmosphere have been retained in it up until the present time. Obviously, in the atmosphere just as in the hydrosphere, there is a system of development and expenditure of gases and vapors. On the one hand, gases continually enter from the interior of the Earth and on the other hand the gases and vapors are constantly expended from the atmosphere. Vapors and gases leave, rushing into the hydrosphere, lithosphere, biosphere and into outer space (hydrogen, helium). /87

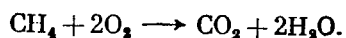
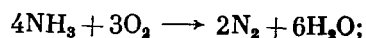
In addition to the quantitative changes in the Earth's atmosphere, its chemical composition is constantly found in dynamic equilibrium. In contrast to the outer planets of the solar system, and also in contrast to the other inner planets, the solar warming of the Earth is such that the presence of water in the atmosphere as an extraordinarily important component becomes possible.

Under conditions of the Earth's atmosphere water vapors are subjected to *photolysis*, and we can not exclude the possibility of *radiolysis*, as a result of which water decomposes to hydrogen and oxygen. The free hydrogen forming in the atmosphere is not accumulated as a result of dissipation into outer space. Free oxygen does not disappear but is accumulated in the atmosphere.

At the present time the content of water vapors in the Earth's atmosphere is estimated at $1.3 \cdot 10^{19}$ g. This means that water vapors in huge amounts are continuously found under the influence of photochemical and radiochemical factors. Byutner [1959] calculated that the rate of photodecomposition of atmospheric water at an altitude of 70-80 km is $10^{12} \text{ cm}^{-2} \cdot \text{sec}^{-1}$. The decomposition of atmospheric water is regulated by the shield, i.e., by the free oxygen thus formed. /88

With respect to this problem, information on the distribution of free oxygen at different altitudes of the atmosphere is worthy of attention. B. A. Mitrov [1961] informs us that in the range of altitudes from 0 to 100 km in the atmosphere the oxygen and nitrogen content in the atmosphere is kept constant. At altitudes from 200 to 500 km, the nitrogen content is less than that of oxygen, while at an altitude of 1000 km the oxygen content becomes predominant. Does this not occur because oxygen enters the upper layers of the Earth's atmosphere in the form of water which, during dissociation at these altitudes, yields oxygen in the form of ions and atoms rather than in the form of molecules?

The appearance of free oxygen in the atmosphere leads to the appearance of reduction-oxidation processes. Gases entering from the mantle under the new physical conditions undergo further evolution. The components of the primary atmosphere (methane and ammonia) are oxidized to carbon dioxide and nitrogen.



When the concentration of water vapors in the atmosphere reaches such dimensions that there is sufficient oxygen being formed from it for the oxidation of all the methane and ammonia, the chemical composition of the atmosphere changes. Oxygen and nitrogen replace methane and ammonia. This secondary composition of the Earth's atmosphere arises not immediately but by means of the gradual and prolonged replacement of the primary components. The primary components have continued to enter the atmosphere up to the present time, but nevertheless they do not accumulate in it although they can be detected. Gases which are continuously entering the atmosphere from the mantle are continuously being oxidized in it. This process in the Earth's atmosphere will continue as long as the internal activity of the Earth is maintained.

On a planetary scale a powerful mechanism for regeneration of the atmosphere is constantly working. Volcanic carbon dioxide and carbon dioxide formed during the oxidation of methane continually enter the atmosphere and are absorbed by the lithosphere, hydrosphere and biosphere. The atmospheric oxygen being expended is compensated during the dissociation of atmospheric water. /89

The viewpoint that as a result of the activity of green plants there occurs a local seasonal gas exchange with the absorption of carbon dioxide and the yielding of oxygen is true and indisputable. However, the viewpoint that regeneration of the atmosphere would have occurred in the absence of green plants must also be true and indisputable. Green plants are not included any sooner in the overall planetary process. This process depends neither on the

region of the Earth's sphere, the climatic conditions nor on the time of year. We can not agree with the assertion that the regeneration of air is connected exclusively with the activity of green plants.

ORGANIC SYNTHESIS IN THE EARTH'S ATMOSPHERE

To enumerate the formation conditions of living matter even in /90 first approximation, we must proceed from the formation conditions for such specific materials as nucleic acids and proteins which are carriers of the material of life phenomena. If we bear in mind that such elements as hydrogen, carbon, nitrogen, oxygen, phosphorous and sulfur are included in the above compounds it is obvious that the presence of structural matter (organogen elements) is the first necessary condition for the formation of living matter. We see that this condition is necessary, but not sufficient, if we bear in mind the fact that organogen elements are found in interstellar space which we find difficult to believe is inhabited.

For living matter to be formed the initial organogen elements must be found in the form of very specific compounds. What are these compounds? Here it is appropriate to cite one viewpoint expressed by V.I. Vernadskiy [1960]: "Almost all organic materials are created from gases. The most important phenomenon in the history of living matter is its gaseous genesis and its conversion to gases after death". Vernadskiy was even more precise about this problem when he cited the words of L. Henderson: "Water and carbon dioxide are materials established on our planet by the blind forces of cosmic evolution and they serve to the utmost to make both the living organism itself and the world and its environment stable, prolonged and complex". This unusual thought is very useful to those authors who are searching for the beginning of life in the spheres of high-molecular organic compounds.

For the appearance of nucleic acids and proteins there is not /91 the slightest need for high-molecular organic compounds. Wide-scale observations convince us that biological polymers (nucleic acids, proteins and carbohydrates) are created during the polymerization of such monomers as water, carbon dioxide, ammonia, hydrogen sulfide and phosphine. Plants and some microorganisms, for example purple bacteria, use carbon dioxide. Some micro- and macro-organisms use ammonia. High-molecular organic compounds, being processed as food in living organisms, in addition to though the stage of depolymerization to monomers, and only then are proteins, fats and carbohydrates created from them.

Polymerization of monomers with the formation of biological polymers does not occur only in living organisms. We know, for

example, from the experiments of A.M. Butlerov, that with ultraviolet radiation the transmission of carbon dioxide through water causes the formation of carbohydrates. We also know that with radiation exposure carbon dioxide with water and ammonia yields carbohydrates, urea and percarbonic acid. The abiogenous synthesis of biological polymers is possible in principle. It is most probable with polymerization processes of such monomers as water, carbon dioxide, ammonia and phosphine. On the basis of conditions under which such a synthesis is possible we are completely justified in assuming its occurrence in the *Earth's atmosphere*.

Gases and vapors continuously enter the Earth's atmosphere from the mantle. These gases, occurring under new physical conditions undergo further evolution. Using free movement and contact in the gas environment of the Earth's atmosphere with natural ultraviolet and radiation exposure the gases and vapors participate in a directed organic synthesis. It is noteworthy that in the composition of volcanic gases all those compounds are found which can serve as organogen monomers for organic synthesis. During the formation of petroleum, parallel processes take place which lead to the formation of hydrocarbons and their derivatives oxygen, nitrogen, sulfur and phosphorous derivatives, and compounds of these elements participate during organic synthesis in the atmosphere. As a result high-molecular copolymers are formed.

The formation of complex compounds is possible because in the atmosphere processes can take place *on the bases of a radical-peroxidized-chain mechanism*. The processes can be caused at first by the photolysis of water into hydrogen and hydroxyl. The appearance of such active centers as the hydrogen atom and the hydroxyl radical can draw the carbon dioxide into the chain process with the formation of radicals, which under atmospheric conditions, can be joined to oxygen with the formation of peroxide compounds. The possibility of the dissociation of the latter into radicals opens the path for further and deeper conversions. /92

We must understand the change in the composition of the primary Earth's atmosphere into the secondary atmosphere more broadly than only as the substitution of oxygen and nitrogen for methane and ammonia. As a result of the course of the organic synthesis processes new components, perhaps seeds of life, are included in the composition of the atmosphere. These new formations, appearing as a component part of the atmosphere, do not have a special form of motion as Vernadskiy assumed. General forms of motion are sufficient for components of the atmosphere to appear where the atmosphere itself has access.

We know that the Earth's atmosphere is rich in different organic and inorganic matter. We must specify which matter is biogenous and which is abiogenous. At the present time there are only studies which show the formation of life under sterile conditions, i.e., where there is only mineral matter. It seems to us that these

experiments will be more successful the more their conditions approach the conditions of the Earth's atmosphere.

If the living matter on the Earth appeared for the first time by abiogenous means, we may naturally assume that the planet never lost this former property and has preserved it up until the present time. Are there sufficient grounds for asserting that abiogenous synthesis on the Earth took place only in the beginning of the formation of the biosphere, and that life being created from a random unrepeating impulse developed further completely independently, that biogenous synthesis on the Earth forced out the abiogenous synthesis and that living matter is created only from living matter (Redy principle)? A. Malakhov in his article "Forbidden Reversals" writes the following: "According to a study by Oparin... once having /93 appeared, life began to submit to the laws of evolution, and this process was never repeated again. All subsequent forms of life developed from these simplest primary formations. Here we discover that we can not practically confirm the hypothesis by paleontological methods... And, finally, why must we consider that the birth of life is some kind of single-act and prolonged process?"

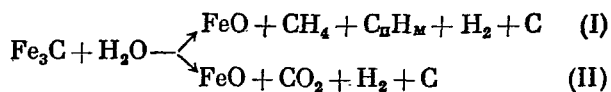
In this case by posing the question "living from nonliving" the same viewpoint is repeated which occurred with the question concerning regeneration of the Earth's atmosphere when, after the process of gas exchange in the green leaf, no background planetary process of atmospheric regeneration was noticed. Now the ability of living matter to reproduce obscures the role of the planet in its constant participation in the propagation and retention of life.

It is difficult to imagine how a planet which produced life as a result of the evolution of planetary matter could then withdraw and stop participating in the development of its biosphere. What could happen to a planet, which had lost its former ability, somehow having stopped the stage of converting mineral matter into organic and finally, into living matter? Although we cannot see those processes which formerly placed the beginning of life on Earth they must exist and even today they can not be stopped.

The essence of the problem probably consists of the sharp contrast between biogenous and abiogenous processes according to the specific concentration of their initial and, subsequently final products. With such a premise it seems we would be more correct in holding to the law of the spontaneous formation of life and in searching for its experimental confirmation. It is precisely in such a plane that recently the problem of the law of conservation of momentum stood. This law remained for more than ten years and investigations were carried out to confirm it. These investigations were successful; the elementary particle neutrino was discovered.

Sources of the process of life formation on Earth began far in the interior of the planet. Iron carbide which, during contact

with deep-seated water, gave rise to two directions of reactions in the parent matter of life



I. The hydrocarbon direction of reaction takes place at a moderate rate and at a moderate temperature. Incidentally, hydrolytic reactions of nitrides, phosphides and sulfides of metals occur with the hydrolysis of carbides. In the final result petroleum which migrates to the Earth's crust is formed.

/94

II. The carbon dioxide reaction takes place under conditions of increased rates and, therefore, at a higher temperature. Incidentally, hydrolysis of nitrides, phosphides and sulfides of metals takes place with the hydrolysis of carbides. In the final result there appears a mixture of gases which also migrate to the Earth's surface. The further evolution of these gases under conditions of the atmosphere leads to the formation of products of organic synthesis.

In studying these two directions of the same reaction of the hydrolysis of iron carbide it is appropriate to cite the following assumption of V.I. Vernadskiy [1960]: "It is obvious that the chemical conditions for the formation of two groups of carbon minerals, oxides and excess oxygen bodies are incompatible with each other. Their existence is perhaps a characteristic of their origin from different depths of the magma. This logical conclusion would seem to be the simplest and has given rise to numerous hypotheses. The history of these concepts shows that all these hypotheses and all the concepts related to them are too simple and that the natural phenomenon is more complex".

The complexity of the natural phenomenon was due to the fact that the hydrolytic reaction of iron carbide could occur in two directions: either with the formation of carbon dioxide or with the formation of hydrocarbons. Temperature affects the direction of the reaction. It is true that at different depths there are different temperatures but at different depths there are also different pressures. To change the direction of a reaction by raising the temperature we must retain the former pressure. Changes in the direction of a reaction can be expected at the same depth with a change in temperature of the reaction zone.

Thus, from the same parent matter in the same reaction zone, but with different changing temperatures, two independent planetary processes began: *the formation of petroleum and the formation of life*. Here, to the question of whether life came from petroleum or, conversely, petroleum came from life we must answer that neither happened.

/95

The hydrocarbon and carbonic acid directions of the hydrolytic reaction of iron carbon are not equivalent either in their ratios or in the following development of their products.

Under planetary conditions the carbonic direction is suppressed by the hydrocarbon direction. However, in spite of its small volume the process of the carbonic direction is very noticeable.

Incidentally, in explaining the relation of life to petroleum we must define more precisely the relation of life to the atmosphere. There is a very widespread opinion that life gave rise to the atmosphere: "...it will be correct to conclude and, in the future to consider that the Earth's gas mantle, our air, has been created by life" Vernadskiy, 1960]. In whatever way such an assertion is expressed, in our opinion it does not have a stable foundation. If we nevertheless pose this question in this form then the assertion about the atmosphere giving rise to life is closer to the truth. More precisely an answer to the question must be the following: as a result of the internal activity of the planet its atmosphere appeared. The atmosphere under the influence of external physical conditions can be in one of three phases: the primary phase (methane-ammonia), secondary (nitrogen-oxygen) and tertiary (carbonic acid) (see below). The evolutionary conversion of mineral matter to organic matter is accomplished only when the atmosphere is in the secondary oxygen phase. The phenomenon of life is due to the approach of a definite phase of the planetary atmosphere. The occurrence of a definite phase of the atmosphere is due not to life but to external and internal conditions of the planet.

The roots of the tree of life which during Darwin's time were at the amoebic level later sank to the cellular level. Still later they sank to a cell nuclear level, then to a chromosome and then to nucleic acids. The molecular level of biology is infinite. From our point of view *the level of organogen monomers* (volcanic gases during whose polymerization biological polymers in the form of nucleic acids are formed) is lower than the molecular level. Even lower than the organogen monomers is *the level in the interior of the Earth* which consists of hydrides, carbides, nitrides, perocides, phosphides and sulfides of metals. All this parent matter for life occurred in space before the formation of the planet from cosmic gases and dust. /96

The formation of living matter on the planet is predetermined by the whole evolutionary course of the matter of the Universe.

The concept that *the planetary atmosphere is the original cradle of life* accounts for a lot. From this it follows that only such bodies as the planets can be carriers of life. All other cosmic bodies can be excluded from our investigation in this respect.

Planets with respect to their masses occupy a very narrow part of the magnitudes in the range, dust particle - star. However, we do not have to extend this part in searching for life in the Universe. Even within this range not all the planets are carriers of life. Moreover, on the inhabited Earth there are zones with very poor forms of life, although life on the Earth is protected against meteorites by the atmosphere, against cosmic rays by the magnetic trap, and against ultraviolet radiation by the ozone barrier.

The boundaries of habitation of planets are sharply limited by the values of their masses and by the external warming of planetary surfaces. All the planets with masses which are not sufficient for atmospheric gravity are excluded from this investigation. Probably *the minimum value of mass for the inhabited planets must be not less than 0.1 of the Earth's mass*. Under conditions of very low external temperatures the planetary atmosphere must be stable and near bodies with a smaller mass. As an example we can take Titan, the satellite of Saturn whose mass is equal to 0.02 of the Earth's mass, but nevertheless has a stable atmosphere consisting of methane and ammonia.

The presence in planets of atmospheres alone still does not determine the possibility of habitation. The planetary atmosphere must have in its composition such an important component as water vapors. This condition is fulfilled only on those planets whose external warming appears within very narrow temperature limits: from the melting point of ice to the temperature for a significant evaporation of water. The freezing of water in planetary reservoirs just as their quick drying excludes the planet from the stage of habitation.

Life on Earth owes its existence not to chance but to those fundamental characteristics of the planet such as its *mass and the solar constant*.^{/97} These two characteristics determine the stable atmosphere on the Earth in the state of the secondary oxygen phase. Of all the phases of the state of planetary atmospheres only this one entails habitation on the planet. On the basis of this external sign we may judge the habitation of other planets. Thus, for example, the primary ammonia phase of Jupiter's atmosphere excludes the possibility of the formation of life on this planet.

The atmosphere of Mars must be found in one of the three possible evolutionary phases. If the phase were the primary state it would be very easy to find methane and ammonia. If these gases are, nevertheless, not found, this means there is oxygen in the atmosphere of Mars which oxidizes the methane to carbon dioxide and the ammonia to nitrogen. The presence of oxygen in the atmosphere of Mars has not been noticed by direct experiment. How-

* Possibly habitation depends on the magnetic field of the planet.

ever, the assumption of nitrogen as the basic component of the atmosphere of Mars may be an indirect proof of the secondary nitrogen-oxygen phase. If this is so, habitation on Mars is very probable.

In addition to their masses a decisive factor for habitation on the Earth and Mars is their solar constants: for the Earth it is $2 \text{ cal}/(\text{cm}^2/\text{min})$, and for Mars $0.8 \text{ cal}/(\text{cm}^2/\text{min})$.

At this stage of our discussion, conditions for the formation of living matter can be formulated in the following way: *habitation can be found on a planet with a mass no lower than 0.1 of the Earth's mass and with an external warming which represents solar constants of $1-2 \text{ cal}/\text{cm}^2/\text{min}$.*

A feature of this formulation was that we contemplated a cosmogonical approach to the characteristics of the formation conditions for living matter. It turns out that living matter and its formation are the result of a special planetary property. *Habitation is a planetary property* and is the logical consequence of a process taking place on the planet at a definite stage in the development of the planet. If a planet is inhabited at a given stage in its development then it cannot be deprived of this property. To whatever vicissitudes life on the planet is subjected, the planet preserves its capacity to be inhabited. In this case there is not the slightest need to export to the planet either structural material for living matter or living matter itself, as many authors would suppose. The evolution of the natural mineral matter of the planet leads to the stage of the possibility of the existence of living matter.

/98

However, the structure of theories on the origin of life does not reflect such logical reasoning. Thus, for example, Oro [1961] considers that with the fall of comets to the Earth the comet matter converts to biochemical compounds without additional energy. Unfortunately Oro is not alone; he has followers. Only by underestimating the nature of the planet and its possibilities can we explain the existence of rather numerous theories which ascribe the formation of the planetary sphere, especially the biosphere, to the entry of cosmic bodies on the planet. Yet, it is quite obvious that cosmic bodies entering a planet can not change anything on the planet either quantitatively or qualitatively. In the first place, this is because nothing can enter from interstellar space which would not be on the planet. In the second place, cosmic body entries to the planet have extraordinarily small relative values with respect to number. Thirdly, the planet is a system with very powerful levers which act in accordance with the physical conditions in its various zones. The development of the planet occurs as the *unavoidable consequence of the processes taking place on it* and in no degree is it subordinate to the blind chance of the fall of cosmic "waste" on it. Just as the stage of habitation forms logically on the planet so this stage must disappear naturally and unavoidably during the later existence of the

planet. A change in the composition of the planetary atmosphere will be the cause for the disappearance of the state of habitation. Habitation appears with the formation of the secondary oxygen phase of the atmosphere and it disappears with the disappearance of this phase. In the second case it is impossible to prolong the stage of habitation on the planet and attempts to graft life on it will be in vain. Existing projects for exporting green plants to Venus which would assimilate the atmospheric carbon dioxide seem impractical to us. For a living plant not only carbon dioxide is necessary. Water is also necessary and if there were water on Venus then it would not be necessary to bring plants in; they would grow there themselves.

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The mass of living matter on the planet is far from an arbitrary magnitude. The value of this magnitude is limited by the amount of organogen elements in the sphere of their circulation (in the biosphere). With a total amount of carbon dioxide entering the Earth's crust of (10^{23} g) its content in living matter is only 0.04%. Thus, this important organogen element is expended unproductively on the planet.

The constant process of the formation of living matter is accompanied by its continuous dying-off process. The shift of the equilibrium of direct and reverse processes in the direction of an increase in the amount of living matter can be achieved by increasing the structural matter in the biosphere. An increase in the volume of structural matter in the biosphere can occur not only as a result of the entry of volcanic gases, but as a result of the redistribution of organogen elements among the planetary spheres. At the present time the activity of man assumes such scales that he exerts a very direct effect on planetary conditions. Thus, for example, if during the next 20 years 60 billion of petroleum are pumped out of the lithosphere and 240 billion of coal are extracted, then during this time 1000 billion T of additional carbon dioxide will enter the hydrosphere and atmosphere. Such processes, however paradoxical, can stimulate reproductive processes of living matter. At the present time on a planetary scale there is a definite tendency toward reduction of the planet world. But thanks to the existing planetary mechanism there is no need to fear an increase in concentration of carbon dioxide in the Earth's atmosphere with respect to regeneration of the atmosphere.

The dependence of the reproduction of living matter on the amount of structural matter can be shown by the fact that living matter having huge potential opportunities for reproduction, actually does not realize these possibilities. In this light, on the one hand it is impossible to recognize the mass of living matter existing at the present time as a planetary constant for any prolonged period of time. And on the other hand, it is impossible to agree with the assumption of the reproduction of mankind on the planet in geometrical progression. The existing condition of the creation and expenditure of living matter on the planet signifies

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neither statics nor intense dynamics. Processes take place whose result becomes noticeable with the lapse of a significant interval of time. However, processes related to the evolution of mineral matter also occur in this way. Thus, for example, with respect to the internal activity of the Earth its mean density for 4.5 billion years changed by two units. Can we notice such changes in a short period of time?

The Earth as an inhabited planet is not unique not only within the Galaxy but within the solar system. It owes its property of habitation to its mass and the Sun which warms the Earth's surface only at a specific interval of time and only to a known degree. However, in view of the fact that the Sun is also evolving temperature changes the external warming of the planet also changes. With the change in the external warming of the planet from the direction of the Sun entirely new conditions of habitation are created on the planets. On some planets habitation may cease and on others it may be formed. If the temperature of the Sun before was lower than modern temperature, then Venus may have been inhabited before while the Earth may have been less inhabited or entirely uninhabited. If in the future the temperature of the Sun is higher, then conditions of habitation may disappear on the Earth, while on Mars more favorable conditions for the development of life will be created. If during the course of time the temperature of the Sun diminishes, the stage of habitation will creep over the planets in reverse order.

There are no grounds for assuming a stage of habitation simultaneously on many planets. There can not be solar constant indices in the limits $1-2 \text{ cal}/(\text{cm}^2/\text{min})$ on several planets simultaneously. If, for example, ethylene glycol with a freezing temperature of -17°C and a boiling temperature of $+200^\circ \text{C}$ had carried out the role of water in living matter the stages of habitation would have been prolonged and simultaneous on several planets.

Millions of stars which might have planets are counted in the Galaxy. According to A.I. Oparin and V.G. Fesenkov [1960] there is one star having inhabited planets per $10^5 - 10^6$ stars. In each of these planetary systems one or two planets are inhabited simultaneously, and a large number of them were, or will be, inhabited at different times. With such a large number of sources of habitation they can be found at very diverse stages in development with respect to time, degree and forms of development of living matter. It is very possible that at the present time there are inhabited planets on which there were more favorable physical and historical conditions for the development of life than on Earth. Under these conditions it is impossible not to assume worlds which are very advanced in development, with a high level of knowledge and culture. We must assume not only that the Earth is not unique among the other planets, but that mankind inhabiting the Earth is not unique among the intelligent inhabitants of other planets of the Galaxy and Universe.

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The matter of the Universe does not disappear, but entering zones with new physical conditions it evolves and changes the form of its existence. Among these changes there is the stage when the matter has the ability to reproduce itself. In the eternally existing Universe intelligent beings as a form of existence of matter are being formed continuously.

THE FUTURE OF THE EARTH

We can predict the future of the Earth on the basis of its developmental tendencies which have been expressed in the past. We must predict especially sharp changes in the Earth's spheres due to extinguishing of the Earth's internal activity. Extinguishing of the internal activity appears as a result of the complete expenditures of primary planetary matter, which is presently included in the intermediate mantle of the Earth. As a result of the disappearance of this mantle the external mantle and core will increase. They will join, probably, at a depth of 2100 km. As a result of the increase in the mass of the core the mean density of the planet will increase and its volume will decrease. Due to the further decrease in the volume the area of the Earth's crust will contract by an additional 72.4 million km². New elevations and depressions equivalent to them which correspond to this area will be formed. The Earth's appearance will undergo significant changes. /102

Let us calculate several characteristics of the future of the Earth. It is known that the mean density of the modern Earth is equal to 5.516. Let us try to calculate the mean density of the modern Earth on the basis of the densities of its mantles and core. Let us take the density of the core as equal to the density of iron under normal conditions (7.9). We will assume that the density of the intermediate zone of the Earth is equal to the mean density of the primary planetary matter found in Table 12 (2.9). We will assume that the density of the outer zone is equal to the mean density of the matter of this zone (3.3), which was determined in Table 17. The mass content of the mantles of the Earth is known from calculations given in Table 14. The calculation of the mean specific gravity of the matter of all three of the Earth's mantles under normal conditions of the matter is given in Table 27.

The calculation given shows that the mean density of the zone matter of the Earth under normal conditions and under conditions which exist in the interior of the planet are different by a value of 0.75. Analogous corrections for the mean density of the matter can be calculated for other planets. We know that the Moon has a mean density of 3.34. The mean density of the matter without correction for the Moon must be similar to the density of the primary planetary matter (2.9). The Moon as a result of its small mass has undergone insignificant development, because on the whole, it consists of primary planetary matter which in other planets makes up the intermediate zone with the same density. /103

TABLE 27

Core and Mantles	Content of Matter		Mean Specific Gravity, g/cm^3
	%	10^{27} g	
Core	35	2.091	7.9
Outer	29.2	1.744	3.3
Intermediate	35.8	2.139	2.9
	100.0	5.974	4.76

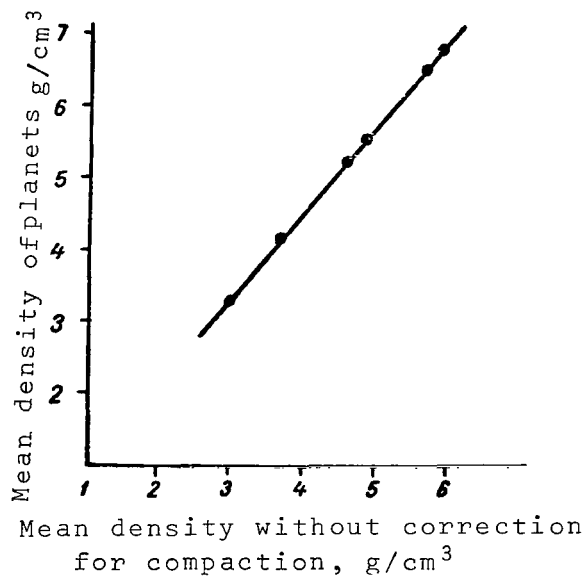


Fig. 3.

On the basis of two characteristics of the mean densities of the Earth (5.516 and 4.76), and also on the basis of two characteristics of the mean densities of the Moon (3.34 and 2.9) let us construct a graph: the mean density of the planet with a correction and the mean density of the planet without a correction. This graph is given in Figure 3 and will be studied later.

Now let us return to the characteristics of the future Earth. The total amount of hydrogen on the young Earth amounted to 1.925% of the Earth's mass (Table 12) or $0.11 \cdot 10^{27}$ g. If we subtract this mass of hydrogen (as having disappeared) from the initial mass of the Earth ($6.01 \cdot 10^{27}$ g) we will obtain the mass of the future Earth ($5.9 \cdot 10^{27}$ g). According to Table 14 the maximum possible mass of the core will equal 54.5%. In this case we observe the ratio of the oxide mantle to the metallic core (1:12). Proceeding from the data given for the future Earth we can calculate the mean density without correction on the basis of the densities of the zone masses. Such a calculation is given in Table 28.

TABLE 28

Zones	Content of Matter		Mean Specific Gravity, g/cm ³
	%	10^{27} g	
Core	54.5	3.21	7.9
Outer	45.5	2.69	3.3
	100.0	5.90	5.8

On the basis of the mean density obtained without correction for the future Earth it is possible, using the graph in Figure 3, to find the mean density with correction. The magnitude sought is equal to 6.8.

The calculations given above now permit us to characterize the past, present and future Earth by the following indices given in Table 29.

From the given characteristics of the Earth at various stages of its evolution only the mass of the planetary core increases with time, and in this respect the mean density increases. The other characteristics diminish in time. The significant decrease in the volume of the Earth includes a decrease in the radius and a contraction of the area of the Earth's crust.

In the future with the cessation of the Earth's internal activity, waters and gases from the interior will stop coming to the

surface of the planet. As before in the gas and water systems of the planet their expenditures will occur but without compensation. This situation will continue until such time as the gases of the atmosphere and the waters of the hydrosphere are expended. Dryness threatens the planet in its subsequent stage of development.

TABLE 29

Characteristics	Earth		
	Past	Modern	Future
Total Mass, 10^{27} g	6.01	5.97	5.90
Mass of the Core, %	0	35	54.5
Total Volume, 10^{27} cm ³	1.56	1.08	0.87
Radius, km	7200	6370	5940
Area of the Crust, million km ³	651.1	509.6	437.2
Mean Density, g/cm ³	3.8	5.52	6.8

Disappearance of the hydrosphere will halt the regeneration processes in the atmosphere and also the processes of organic synthesis. All this will lead to the accumulation of carbon dioxide in the atmosphere and to the disappearance of habitation conditions. The carbon dioxide of three spheres will be concentrated in one atmosphere. This will be the tertiary carbonic acid phase of the planetary atmosphere.

With the extinction of the internal activity of the Earth, in the body of the planet sharp changes in structure will become unavoidable due to the nonuniform cooling of the various zones. We must expect especially sharp differences at the boundary between the core and the oxide mantle. Powerful stresses arising here will lead to a weakening and rupture in the connections between the individual zones of the planetary body. The collapse of the planet will be unavoidable. In this case the matter in its evolutionary development will complete the cycle: cosmic dust - planet - cosmic dust.

If we bear in mind the fact that the Earth with respect to its mass and therefore, with respect to its rates of development lags behind the outer planets, and even more so behind the Sun, then it may happen that the Earth, before reaching the stage of extinction, will be drawn into the events which result from the collapse of larger bodies of the Solar system.

OTHER PLANETS OF THE SOLAR SYSTEM

If all the planets of the solar system, formed from the same planetary matter, had the same mass, there would still be no reason to expect a complete uniformity of the planets. They would all possess absolutely identical rates of development with respect to internal activity and with respect to the formation of planetary mantles and spheres. But nevertheless, different rotational velocities and different distances from the Sun would affect their development. The nature of the volcanic activity and the formation of the planetary crust depend on the rotation of bodies. The external warming and state of the atmosphere, biosphere and hydrosphere depend on the distance of the planet from the Sun. /106

Differences among the planets are much more noticeable when the planets have different masses. In this case the differences arising from different rates of development influence the nature of the planet. With a lapse of the same time planets with different masses end their evolutionary development with a different ratio of masses, core and mantles. This directly affects the mean densities of the planets. Therefore, we must recognize the mean density of the planet as an important characteristic of its condition.

If we determine the density of lunar matter under normal conditions mainly by the density of the primary planetary matter (2.9) and this matter under lunar conditions has a mean density of 3.3 we must then recognize that the correction for the self-packing and compaction of the matter is 0.4. If we also take into account the fact that the mean density which we calculated before for the Earth does not include a correction for the self-packing and compaction of the matter, then on the basis of two known points we can construct a graph: the mean density of the planets with correction for compaction and the mean density of the planets without correction for compaction. This graph is given in Figure 3. /107

From the graph the following characteristics of the mean densities of planets without corrections for compaction (Table 30) result.

Of the three possible planetary zones the core is of decisive importance for the mean density of the planet. A direct relationship must exist between the mass of the core and the mean density of the planet without correction for compaction. To construct a

graph: mean density of the planet without correction for compaction - mass of the core (in per cent), let us take for the modern Earth the mean density without correction for compaction of the matter (4.7) with a core mass of 35%, and for the future Earth the mean density without a correction for compaction of the matter (5.8) with a core mass of 54.5%. This graph is presented in Figure 4.

From this graph we obtain the following characteristics of planetary cores (Table 31).

TABLE 30

Planets	Mean Density, g/cm ³	
	with correction for compaction	without correction for compaction
Moon	3.3	2.9
Mars	4.1	3.55
Venus	5.2	4.5
Modern Earth	5.5	4.7
Future Earth	6.8	5.8
Mercury	5.6	4.7
Jupiter	6.5	5.65

TABLE 31

Planets	Mass, 10 ²⁷ g	Size of core, %
Moon	0.07	3.5
Mars	0.66	15
Venus	4.86	31.3
Earth	5.97	35
Mercury	0.33	37.5

If we bear in mind that the formation of planetary cores is accompanied by a decrease in volumes then for each planet it is possible to calculate its primary volume. In Table 32 we give a calculation for the compaction of the various planets. /108

Since the intensity of the internal activity of the planet is a function of its total mass, then the size of the planetary core is also a function of the total mass of the planet. The size of the core reflects the intensity of the internal activity. Only Mercury is an exception, because the mass of its core in percent is more than the Earth's core and its total mass is significantly

less than the Earth's mass. The cause of this discrepancy, we think, is a catastrophe which the planet underwent in the past.

TABLE 32

Planets	Decrease in Volume, 10^{27} cm^3
Mars	0.023
Venus	0.336
Modern Earth	0.480
Future Earth	0.760
Mercury	0.028
Moon	0.0007

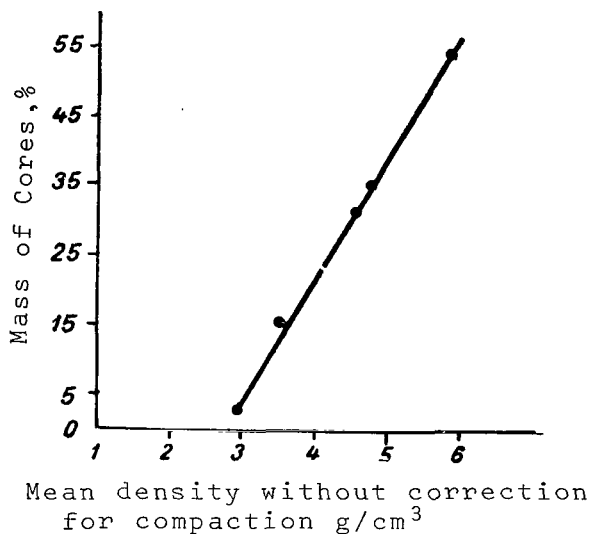


Fig. 4.

At the present time Mercury is a remnant of a past planet whose dimensions corresponded earlier to the modern mass of the planetary core. Earlier this planet was not separated from a number of other planets on the basis of its mean density characteristics. We will say more about this in detail below. /109

Apropos of the results of our calculation of the planetary core dimensions we must mention the theory of Ramsay and Lodochnikov. These investigators exclude the possibility of the existence of planetary cores. They ascribe changes in the density of the planets to phase transfers of matter under the effect of high pressures.

Experiments which have been performed, however, do not confirm the concept of coreless planets. During an experimental compaction of dunite to 1.4 million atm, no phase transfers of matter were observed. Mercury (0.05 of the Earth's mass and mean density 5.6) and the satellite Triton (0.02 of the Earth's mass and mean density 4.9) not only do not support the theory of coreless planets but are in complete opposition to it. In addition, the advocates of the phase transfers of matter in planets must tell us why iron meteorites exist.

B.Yu. Levin is among the advocates of the theory of Ramsay and Lodochnikov. He cites the following arguments in support of the theory:

(1) It is difficult to assume gravitational differentiation of matter within the Earth under high pressures at a significant rate which leads to the formation of a metallic core.

(2) In the composition of the Earth there is not a sufficient amount of iron for the formation of significant cores.

(3) The nonuniformity of the Earth can be explained by its growth as a result of the fall of large meteorites on it.

With respect to these arguments we can express the following considerations:

(1) If we judge the possibility of the differentiation of matter in the body of the planet only on the basis of gravitation then actually it would scarcely be possible to expect the formation of an iron core. In such case we also could not expect the formation of planetary spheres. However, they were formed. Therefore, the differentiation of matter in the body of the planet is determined not so much by gravitation as other causes. /110

(2) According to Levin the small amount of iron on the planet comes from his assumption that the composition of the planet corresponds to the composition of iron and stony meteorites in a ratio of 1:6. With such a ratio of meteorites, in fact, he obtains an apparently insufficient content of iron for the formation of the core. To overcome this difficulty we must take another ratio of iron and stony meteorites. Then there will be enough iron for the core and some will remain for the outer mantles of the Earth.

(3) With respect to the growth of the Earth as a result of large meteorites we must note that in the first place during the stage of the Earth's formation there were still no meteorites in interplanetary space. They appeared later with the decomposition of some already-formed planets. In the second place, can a fundamental property of the planets change its density as a result of the evolution of the planetary matter and can it conform to blind fate (i.e., whether or not a meteorite will fall on the planet)?

If we continue the concept accepted about the formation of the Earth as a result of large meteorites we must assume that the Moon was formed with a high density as a result of small meteorites. When we must explain the formation of a planet with a very low density then we deny the participation of meteorites in its formation. Here, incidentally, we deny not only cores but also solid bodies. The hydrogen model of Jupiter can serve as an example. The hydrogen model for the construction of the model of Saturn whose mean density is 2 times less than the density of Jupiter, can not justify this viewpoint. We are completely justified in saying that all the variations of the coreless planet theories do not bring us closer to the solution of the problem.

Using the data obtained about the sizes of cores for the various planets, we can calculate the masses of their mantles. Such a calculation is given in Table 33.

Along with the formation of mantles in planets, planetary spheres are also formed. By the example of the Earth we can see the very complex dependence of the masses of the atmosphere and hydrosphere on many factors. All these factors are different in the different planets and it is very difficult to derive any direct function on the basis of the Earth's characteristics.

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TABLE 33

Planets	Mass of Mantles, wt. %		
	Core	Outer	Intermediate
Moon	4	3	93
Mars	14	11	75
Venus	30	23	47
Earth	35	27	38
Mercury	37	—	63

TABLE 34

Planets	Mass of the Converted Matter, 10^{27} g	Mass of the Formed Hydrosphere (in Pacific Oceans)	Discharge of Water in the Atmospheres
Moon	0.005	0.001	0.001
Mars	0.17	0.05	0.01
Venus	2.57	0.85	0.85
Earth	3.70	1.22	0.22

In Table 34 we give an approximate calculation of the hydrospheres of the planets on the basis of the mass of the converted matter on each planet.

In this calculation we consider not the complete yield of water with the deep-seated processes, but rather that part of it which appeared on the surface of the planet. The remaining mass of the water formed is distributed along the entire stratum of the mantle. Something different happens to the water which has separated out onto the surface of the different planets. In one extreme case all the water entering the surface of the planet forms the hydrosphere. In the other extreme case all the water entering the surface of the planet evaporates into the atmosphere and does not form any hydrosphere. In the intermediate cases variants with the

partial formation of hydrospheres on the planets are possible. Under the Earth's conditions the water system was such that the expenditure of water lagged behind its appearance. As a result of these conditions water in the Earth's reservoirs accumulated in the amount of $0.164 \cdot 10^{25}$ g (Pacific Ocean). /112

Mars

The water system on Mars can serve as an example of a water system like that on Earth. On the basis of a very approximate calculation the entry of water to the surface of Mars may amount to 0.05 of the Pacific Ocean. The expenditure of water on this planet must be lower than under terrestrial conditions since with a mean annual temperature at the equator of $-(10-20)^{\circ}\text{C}$ the reservoirs of Mars are under an ice cover for a long time.

If on Mars there were generally no expenditures of water then its atmosphere, with respect to its composition, would be a primary ammonia one. Since neither methane nor ammonia is found in Mars' atmosphere we must suppose that they are oxidized to carbon dioxide and nitrogen. Carbon dioxide has been found in the atmosphere of Mars. We assume that the atmosphere of Mars consists primarily of nitrogen. On the basis of the expenditure of oxygen for oxidation of the Earth's crust we can calculate the expenditure of oxygen for the oxidation of the crust of Mars, and on the basis of the oxygen we can determine the expenditure of water. Such a calculation yields an expenditure of water in an amount of 0.01 of the Pacific Ocean for Mars. Therefore, the modern ocean of Mars is equal to 0.04 of the Pacific Ocean.

The presence of the hydrosphere and the possible flow of reduction-oxidation processes in the atmosphere of Mars are prerequisites for the appearance of habitation on this planet. On the dry land of Mars we can assume only elementary forms of life. A greater variation in the forms of life can be assumed in its hydrosphere where the conditions of temperature and pressure and the protection from cosmic radiation are more favorable than on dry land.

Available observations of Mars testify to a sufficiently low external temperature, to decreased gravitation and to the appearance of internal planetary activity which is accompanied by volcanic activity. The flares observed on the surface of Mars, in our opinion, are flashes from water fountains formed with the activity of subterranean volcanoes. With respect to the nature and duration of the flares they are more similar to water fountains than to eruption products. /113

Some other investigators assume the existence on Mars of a hydrosphere and biosphere and the appearance of volcanic activity. A.I. Lebedinskiy and G.I. Salova [1962], on the basis of the degree of turbidity of the atmosphere and the speed of evaporation of the polar caprocks estimated the amount of free water on Mars at $2 \cdot 10^{15}$ g.

V.D. Davydov [1960] explains the low density of the water vapors in the atmosphere of Mars not by the insufficiency of water but rather by the low temperature at which the atmospheric water freezes. The total amount of water on Mars, in his opinion, is 1 km^3 per 1 km^2 of the whole area of the planet.

According to photographs obtained by the American rocket "Salingier" the surface of Mars is characterized by the presence of ring-shaped structures. If the whole surface of Mars is the same as the photographed part the total amount of cirques must be on the order of 10,000. On the basis of analyzing the photographs, American investigators have concluded that there is no water on Mars. They neither affirm life on Mars nor deny it.

With respect to the conclusions of the American investigators we must note the following. It is probably still premature to make an overall conclusion about the whole surface of Mars on the basis of photographs of individual parts of its surface. As we know, photographs of Mars reflect the surface of the planet from a distance of 9-10 thousand km. In this respect there arises the question of whether from this distance it is possible to establish or not the presence of water under the conditions on Mars, especially when it covered with ice which can, moreover, be covered by some rock layer during the occurrence of dust storms. If there is, nevertheless, no water on Mars, American investigators might be able to speak out more definitely with respect to life on this planet. Can we, denying the presence of water on the planet, not deny the presence of life on the planet?

According to more recent communications, on the basis of photographs a white deposit reminiscent of frost has been established on swells of a crater. This is exactly what we must prove since under the physical conditions on the surface of Mars the prolonged existence of open reservoirs with liquid water is excluded.

Denying a hydrosphere on Mars would create significant difficulties in explaining the observed flashes, the appearance and disappearance of polar caprocks and the absence in the atmosphere of methane and ammonia. It would be difficult to establish the differences between Mars and the Moon. Mars, in comparison with the Moon, has 1.3 times higher density and a 9 times greater total mass. The difference in such important characteristics obliges us, after external analogies of the surface structures, not to lose sight of the principal features of each planet. The large mass of Mars entails a more intense internal activity and, therefore, larger planetary spheres with respect to mass. The best photographs of the planets do not justify breaking away from those conclusions which result from the physical essence of a celestial body. /114

The Moon

The water systems on the Moon, Venus and Mercury can serve as examples of other water systems besides those of Earth and Mars.

We must investigate the Moon as a body having internal activity. However, the intensity of the deep-seated processes is determined by the insignificant total mass of the Moon. The rates of the differentiation processes of the lunar matter are found with respect to this. During the formation of the internal activity the lunar core achieved dimensions amounting to only 4% of the total mass, while the lunar crust may be only a thin stratum. The gases coming onto the surface do not form a stable atmosphere, and water in the amount of 0.001 of the Pacific Ocean also was not retained in the lunar reservoirs but disappeared.

The absence on the Moon of a hydrosphere and atmosphere unambiguously testifies to the nonhabitation of this celestial body. There are no conditions on it for the formation of living matter and also for the existence of living matter if it were exported. The lunar surface continuously serves as an arena on which physical chemical, radio chemical and radiation processes occur which are the result of the supply of solar light and heat, the activity of cosmic rays and the fall of meteorites. However, the face of the Moon is generally not determined by these external factors. On the Moon, as on the Earth, there are internal forces which form the surface stratum of the body.

Numerous photographs of the surface of the Moon testify to the /115 fact that on it there are a large number of relief elements with different dimensions but with an overall ring-shaped form. The American investigator Green (1965), comparing photographs of the Moon with photographs of the Earth's volcanic craters, concluded that the lunar surface was of volcanic origin. Here Green explains several formations of the ring-shaped form by the fall of meteorites. It seems to us that the method of analogies can lead directly to the reverse conclusion: the surface of the Moon, on the whole, just as the surface of the Earth, is not volcanic in origin. In fact, there are few volcanic craters on the Earth, and the volcanic processes themselves play a very insignificant role in the formation of the Earth's crust.

From our point of view, it is impossible to explain the structural formations on the lunar surface without taking into account the compaction processes of the lunar body. According to calculations given in Table 32, the volume of the Moon during its internal activity decreased by $0.07 \cdot 10^{25} \text{ cm}^3$. This amounts to 3% of the modern volume of the Moon. Such a compaction could not affect the structure of the lunar surface in the general outline (seas and continents). The ring-shaped formations on the surface of the Moon are the result of the yield of deep-seated matter to the surface. We must assume that these formations are characteristic of all

bodies possessing internal activity. Photographs of Mars also confirm this assumption. Such structural formations may have occurred on the surface of the young Earth in the foundations of the kimberlite tubes. Subsequently, with the growth of the crust the Earth lost this external form which is peculiar to the modern Moon and Mars with their very thin crusts.

Venus

Venus has a mass similar to the Earth's mass. This is perhaps the only criterion which both planets have in common. In everything else Venus is a very unusual planet. Its first distinguishing feature is its small rotational velocity. With respect to this feature, forces connected with rotation did not participate in the formation of the external shape. Therefore, very deep depressions could not be formed and were confined to the equatorial zone. Its surface may be an alternation of equally large and moderate elevations with similar depressions. These depressions at the present time may represent seas with a total mass of water of 0.85 of the Pacific Ocean. This figure was obtained by an earlier calculation of the mass of water entering the surface of the planets (Table 34). However, in fact, no formation of a hydrosphere on Venus could occur because the solar constant of Venus has very high value equal to $3.6 \text{ cal}/(\text{cm}^2/\text{min})$. Can we expect significant condensation of water vapors in the atmosphere of Venus under conditions of such an external warming if under terrestrial conditions with a solar constant of $1.9 \text{ cal}/(\text{cm}^2/\text{min})$ water continuously remains in the atmosphere in a vaporous state in the amount of $1.3 \cdot 10^{19} \text{ g}$? The continuous expenditure of water during photolysis is due to such a form of its existence. According to the calculation given in Table 26 this expenditure for Earth is 0.22 of the Pacific Ocean. /116

The temperature conditions on Venus, in contrast to those on Earth, are complicated by the fact that a so-called "greenhouse" effect is created on Venus. The atmosphere, saturated with water vapors, preserves transparency for solar rays but is slightly transparent for a large part of infrared radiation emitted by the surface of Venus. All this causes a high warming of the surface of the planet. Measurements of the temperature of Venus yield values of several hundred degrees. We must predict features in the formation of the upper strata of its crust in light of this. The decomposition of migrating fluids in the crust does not reach those stages which occur under low-temperature conditions in the Earth's crust. In addition, the deep-seated water of Venus during the yield to the surface does not condense and does not participate in the formation of the sedimentary stratum of the crust.

As a result of the fact that photolysis of water occurs in the atmosphere of Venus, free oxygen and free hydrogen are formed. Hydrogen rises into the upper zones of the atmosphere and disappears. The problem of the possibility of the dissipation of oxygen under atmospheric conditions of Venus is of interest. V.I. Vernadskiy

[1965] assumed such a possibility for oxygen atoms which are contained in the Earth's ionosphere. For Venus such a possibility is even more probable. Free oxygen in the atmosphere continuously oxidizes methane and ammonia, coming from the interior of Venus, to carbon dioxide and nitrogen. If these oxidizing processes did not occur in the atmosphere of Venus then we could easily find ammonia and methane. But we do not. Volcanic carbon dioxide entering the atmosphere and carbon dioxide appearing in the atmosphere with the oxidation of methane are not distributed between the hydrosphere and biosphere because these do not exist on Venus, and they are concentrated only in the atmosphere. Hence, the peculiarity of the atmosphere of Venus results. The chemical composition of this atmosphere must be the following: nitrogen, oxygen, carbon dioxide and water vapors. Hydrogen is possible in its outer zones. /117

The presence of significant amounts of carbon dioxide in Venus' atmosphere has been known for sometime. Later V.K. Prokof'yev [1964] established an insignificant amount of oxygen in the upper layers of its atmosphere. Now we know that water icicles have been found in the atmosphere of Venus.

Apropos of the above data on the presence of water in the atmosphere of Venus there arises the question of how these data can agree with those results of our calculations according to which water must enter the surface of Venus in the amount of 0.85 of the Pacific Ocean. In the first place, we must recall that our calculations were very approximate. The creation and expenditure of water were calculated in proportion to the masses of the planets. In the second place, it is quite possible that under the conditions on Venus, in contrast to the Earth's conditions, the creation of water is too low and the expenditure of water is too high. In the third place, available observational results still do not give such guarantees of knowledge about the complex system represented by Venus' atmosphere that from these viewpoints we can categorically affirm or deny them.

The internal structure of the body of the planet must be characterized by the presence of a core with a mass amounting to approximately 30% of the total mass of the planet and by the presence of three reaction zones. However, with such a structure of the planet no magnetic field is found on it. The actual absence of a magnetic field on Venus confirms the possibility of the existence of a core. The existence of a core in Venus results from such an important characteristic as the mean density of the planet. The absence of a magnetic field must be ascribed to the low rotational velocity. In this case in the reaction strata of Venus the plastic matter is not brought into motion sufficiently for the appearance of electromagnetic phenomena. /118

The uniqueness of Venus appears with respect to its habitation. On the one hand the flow of reduction-oxidation reactions in its

atmosphere is a prerequisite for organic synthesis in the atmosphere, but on the other hand the high temperature of the surface of the planet and the absence of a hydrosphere exclude the possibility of the development of any forms of life. Venus is an uninhabited planet.

Mercury

One peculiarity of the planet Mercury is that with a total mass equal to 0.054 of the Earth's mass, the mean density of Mercury is higher than that of the Earth, i.e., it is 5.6. On the basis of this characteristic, Mercury is not included in the orderly series of the other planets. This fact has caused several investigators to assume another chemical composition of the planet.

It seems to us that the deviation in density occurred not during the formation of the planet but at a comparatively later time. Let us try to show this on the basis of calculations. Earlier, in Table 31, we determined that the mass of the core of Mercury is $0.12 \cdot 10^{27}$ g and amounts to 37% of the total mass of the modern planet. The mass of the mantle is $0.21 \cdot 10^{27}$ g. If we retain the ratio of the outer zone of the planet to its core (1:1.2), as results from Table 14, then the outer zone with a mass of $0.09 \cdot 10^{27}$ g and the intermediate zone with a mass of $0.58 \cdot 10^{27}$ g must correspond to the mass of the core. In such a case the planet would have a total mass of $0.79 \cdot 10^{27}$ g where the mass of the core would amount to 15% rather than 37% and the mean density is not 5.6 but only 3.95. All these logical characteristics were peculiar to Mercury in its past. Subsequently, obviously as a result of a catastrophe, the planet lost 60% of its mass at the expense of its outer and, partially, its intermediate mantle. At the present time it is a remnant of the former planet and consists of a metallic core surrounded by a layer of the primary planetary matter which was in the intermediate mantle before.

If Mercury had not experienced a collapse then at the present time this planet, with respect to its mass, would have occupied the intermediate place between Mars and Venus and the internal activity of Mercury would not have ceased. As a result the growth of its core would not have stopped and at the present time its mass would have reached 18%. If the internal activity of Mercury began 2 billion years ago then the collapse of Mercury occurred on the order of 300 million years ago. The radius of the former body of the planet may have been 3700 km, while the modern radius is 2400 km. This means that the breaking-up of the planet occurred at a depth of 1300 km. The reaction stratum of the planet was probably situated close to this depth. /119

With the collapse of Mercury interplanetary space filled with fragments reflecting the composition of its outer and intermediate mantles. With the decomposition of the planet iron meteorites

could not form since its core did not undergo destruction. If the fragments had maintained the orbit of the planet then probably we would have been able to observe them. It is very possible that they scattered and are moving in their own orbits. V.G. Fesenkov (1949) informs us that asteroids which occur between Mars and Jupiter, scatter with time. Orbits of several of these have already extended beyond Saturn's orbit.

A feature of the state of the modern Mercury is that with the insignificant mass of its outer mantle there is little probability of internal activity. The primary planetary matter not covered by the crust undergoes a sufficiently high warming from the direction of the Sun, especially when the planet is in the perihelion zone. It seems to us that such observations as the observation of the change in the surface of Mercury during exit from the perihelion zone, the discovery by N.A. Kozyrev of hydrogen in the atmosphere of Mercury and the discovery of carbon dioxide by V. Moroz reflect the external activity of Mercury very well.

In assuming the collapse of Mercury we are not introducing something uncharacteristic of a planet. With respect to very general considerations a planet must have a beginning and an end. The problem is only when and under what conditions the end of a planet occurs. The collapses of such celestial bodies as comets are being observed at the present time. Planetary fragments in interplanetary space testify to the collapses of planets.

The considerations that Mercury was formed in a protoplanetary cloud such as can be observed at the present time seem unconvincing to us. In the first place the concept of the high densities of only those planets situated close to the Sun is not true. In the second place, it is impossible not to assume changes in Mercury during billions of years under conditions which are new for it in comparison to the protoplanetary cloud conditions. Finally, in the third place, if we assume that the matter of modern Mercury is unchanging matter of a primary nebula then we must describe it on the basis of a composition with a mean density of the planet of 5.6. Our calculations show that the modern Mercury is 37% metallic iron. Metallic iron is not a sign of primary matter of a primary nebula but rather processes matter of the internally active planet. The collapse of Mercury may have occurred precisely as a result of the internal activity of the planet.

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Jupiter

The mean density of Jupiter is 1.34. This very low mean density index can testify to the fact that the body of the planet is surrounded by a very extended atmosphere. If we express the volume and mass of Jupiter in earth units and relate the volume to the mass it then turns out that Jupiter grew 4.116 times more in volume than in mass.

Volume, earth units.....1306.5
 Mass, earth units.....317.38
 Ratio of Volume to Mass.....4.116

Such a growth in volume in comparison with the growth in mass must be the result of the volume of Jupiter's atmosphere. If this is so, then by calculation we can obtain the basic characteristics for the body of the planet and separately for its atmosphere. We calculated the mass of the atmosphere on the basis of the Klayperon-Mendeleyev formula

$$m = \frac{Mpv}{RT}.$$

We determined the volume of the atmosphere from the total volume of the planet; since it was 4.116 times larger than the volume of the body of the planet its value can be 1.138.27 liters. With the volume found the radius of the atmosphere could be 29,265 km. If the pressure of the Earth's atmosphere is generally determined by the thickness of the air at 100 km then the atmospheric pressure on Jupiter can equal 292.65 of the Earth's atmosphere. Under conditions of the Earth at a temperature of 223° K at the height of a rarefied atmosphere the normal temperature is 273° K, and under conditions of Jupiter at a temperature of 100° K (Ye. Epik, 1962) at the outer boundary of the atmosphere we must take 163° K as the normal temperature. The mean molecular weight of the atmosphere of Jupiter is determined mainly by hydrogen; it is taken as 2.0. As a result of the calculation, the mass of Jupiter's atmosphere obtained is $50.0 \cdot 10^{27}$ g.

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In Table 35 the basic characteristics for the body of Jupiter and separately for its atmosphere are given.

TABLE 35

Jupiter	Mass, 10 ²⁷ g	Volume, 10 ²⁷ cm ³	Mean Density, g/cm ³	Radius, km
Body of the Planet	1846.0	283	6.52	40420
Atmosphere	50.0	1132	0.044	29265
	1896	1415	1.34	69685

From the above calculation we see that the mass of the atmosphere of Jupiter exceeds by 16.5 million times the mass of the Earth's atmosphere. Naturally such an atmosphere must occupy a very great volume. The high density of the atmosphere is caused

by the fact that in its lower layers a high pressure predominates and in the upper layers a low temperature predominates. Both raise the density of the atmosphere of the planet.

At first glance we can show that the calculated density of the body of the planet is insufficiently large in comparison to the density of the Earth. The difference amounts to 1.0. However, we must notice that the mean density of the planets is generally determined not so much by the total mass as by the mass of the core. The total mass of Mercury is small but nevertheless its density exceeds the density of the Earth.

Although the obtained calculated characteristics are presented separately with respect to the body of the planet and its atmosphere they agree with reliable characteristics of the total mass and its total volume. In addition, the characteristics for the body of the planet and for the atmosphere are related values; the arbitrary overstating of the density of the body unavoidably leads to the unassumed understating of the density of the atmosphere.

For further study of the body of Jupiter let us apply the same /122 method which we used to study the Earth. By means of the graph in Figure 3 let us establish that Jupiter with a mean density of 6.5 must have a density without correction for compaction of 5.6. On the basis of this last characteristic let us establish, by means of the graph in Figure 4, that the mass of the core of Jupiter amounts to 51%. Bearing in mind that the ratio of the outer mantle of the planet to the core is 1:1.2 (on the basis of Table 14) let us calculate the masses of the core and mantles (Table 36).

TABLE 36

Mantles and Core of Jupiter	Mass, 10^{27} g	Mean Density, g/cm ³
Core	966.9	7.9
Outer	805.7	3.3
Intermediate	123.3	2.9
	1895.9	5.6

In this calculation the mean densities of the mantles are taken just as for the Earth. The total index of Jupiter's density without correction for compaction was equal to 5.6. This result of the calculation coincided precisely with that obtained earlier on the basis of the graph in Figure 3. If we bear in mind that the extreme value for planetary cores is 54.4% and that at the present time the size of Jupiter's core is 51% then we can make a conclusion with respect to the future of Jupiter. The internal activity and the volcanic activity of Jupiter will be prolonged for

for about 300 million years.

We may assume that conditions in the spheres of Jupiter are different from conditions of the Earth's spheres. If the creation and expenditure of matter are characteristic of the Earth's spheres, then in Jupiter's spheres only the creation of matter may occur. Here in the spheres those processes which cause the expenditure of matter are halted. The hydrosphere of Jupiter is covered by perpetual ice. Therefore, the possibility of the evaporation of water into the atmosphere is excluded. The absence of water vapors in the atmosphere excludes the possibility of the oxidation of methane and ammonia. This causes these gases to accumulate in the atmosphere. In the atmosphere hydrogen is found entering from the interior. This means that under the conditions on Jupiter, hydrogen either does not disappear or it disappears only partially. /123

Further, if we bear in mind that the outer mantle of Jupiter is $805.7 \cdot 10^{27}$ g, then according to Table 16 with the formation of this mantle volatile compounds of light elements in an amount of 6.145% of the mass of the mantle or $49.5 \cdot 10^{27}$ g are formed. Of this amount $36 \cdot 10^{27}$ g are hydrogen. It is understood that not this whole amount of volatile compounds forms the atmosphere of Jupiter. Nevertheless, we must recognize the convergence of calculations on the basis of the mass of the atmosphere as satisfactory.

A strange thing happened to this giant planet. Jupiter with its mass may have developed an intense internal activity with a large yield of internal energy. However, the external warming of the planet was very low. With a solar constant of $0.07 \text{ cal/cm}^2/\text{min}$) the matter of the outer planetary spheres did not develop to an acceptable stage with respect to conditions for the existence of living matter. This will not occur in the future because little time remains prior to the end of the internal activity of Jupiter. The assertion by I.S. Shklovskiy that the major planets can be considered more suitable shelters for life, from our point of view, is groundless. Jupiter does not have a secondary nitrogen-oxygen atmosphere which can give rise to a stage of habitation.

Saturn, Neptune, Uranus

For the outer planets of the solar system extremely inconsistent changes in the mean densities are observed (Table 38).

TABLE 38*

Planets	Mean Density, g/cm ³
Jupiter	1.34
Saturn	0.70
Neptuen	1.60
Uranus	1.48

As in the case of Jupiter let us express the indices of the volumes and masses of the outer planets in earth units and let us find the ratio of volumes to masses (Table 39).

The ratio of volumes to masses is a function of the external tem-

*No Table 37 in the foreign text.

perature of the planet, the degree of dissipation of hydrogen, the degree of freezing out of the gaseous components of the atmosphere and the degree of consolidation of gases under the pressure of the mass. To find the influence of all these factors on the volume of the planet we can calculate the volumes of the bodies and the atmospheres of the planets separately. First, let us calculate the masses of the bodies and the atmospheres of the planets. On the basis of this calculation let us set the ratio of the masses of the body of the planet and the atmosphere for Jupiter. Any error involved here will not affect the calculations for the bodies of the planets at all because the relative mass of the atmospheres is very small. The results of the calculations are given in Table 40. /124

TABLE 39

Planets	Volume, Earth Units	Mass, Earth Units	Ratio of Volume to Mass
Saturn	743	95.03	7.82
Neptune	64.4	17.24	3.74
Uranus	58.8	14.56	4.05

TABLE 40

Planets	Mass, 10^{27} g	
	Body	Atmosphere
Saturn	552.6	14.9
Neptune	100.3	2.7
Uranus	84.7	2.3

In this calculation not the masses of the atmosphere but the masses of the bodies of the planets are determined with small error. Therefore, to carry out further calculations of planetary bodies makes sense. To establish a more accurate volume of planetary bodies we can perform a calculation via a stage of determining the mean density. For this we must determine the masses of the mantles and cores. Since the masses of the cores are direct functions of the total mass of the planets, let us construct a graph on the basis of this function. As the base of the graph two known points can be placed: the total mass of the Earth taken as 1 with the mass of the core equal to 35% and the total mass of Jupiter equal to 317 earth units with a core mass equal to 51%.

From the graph constructed (Fig. 5), characteristics for planetary cores result and are given in Table 41. /125

TABLE 41

Planets	Mass of the body, earth units	Mass of the core, %
Saturn	94.8	39.8
Neptune	17.1	35.8
Uranus	14.4	35.65

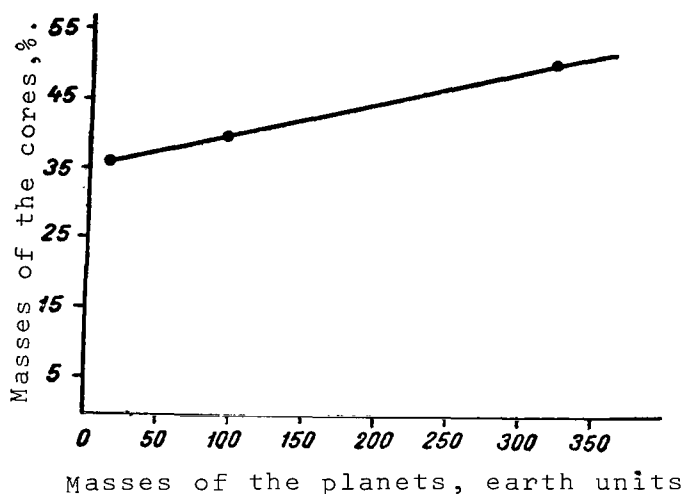


Fig. 5.

On the basis of the masses of the planetary cores we can determine the masses of the planetary mantles, bearing in mind that the outer mantle and the core are found in a 1:1.2 ratio, while the intermediate mantle is determined on the basis of the difference in masses. Calculation of the masses of the mantles and cores is given in Table 42.

On the basis of the obtained masses of the cores and mantles of the outer planets let us determine their mean densities without corrections for compaction (as in the calculations given in Table 27). Further, let us establish the mean densities of these planets with corrections for compaction (as in the calculations given in Table 30). Both characteristics of the mean density of the planets are given in Table 43.

Arranging the data on the mass and density of the planetary bodies, we can determine their volumes. Further, on the basis of the difference in the total volumes of the planets and the volumes of the planetary bodies the volumes of the planetary atmospheres are found. Knowing the volumes and masses of the atmospheres permits finding their mean densities. All the calculations cited are given in Table 44.

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TABLE 42

Planets	Mass, 10^{27} g		
	Core	Mantles	
		Outer	Intermediate
Saturn	220.0	183.3	149.3
Neptune	35.9	30.0	34.4
Uranus	30.2	25.2	29.3

TABLE 43

Planets	Mean Densities of the Bodies of the Planets	
	Without Correction for Compaction	With Correction for Compaction
Saturn	5.02	5.80
Neptune	4.81	5.54
Uranus	4.80	5.51

TABLE 44

Planets	Volumes, 10^{27} cm ³		Mean Density of the Atmosphere, g/cm ³
	Body	Atmosphere	
Saturn	95.3	715.4	0.021
Neptune	18.1	56.3	0.048
Uranus	15.4	43.4	0.053

TABLE 45

Planets	Radius, km		
	Body	Atmosphere	Total
Saturn	20 765	37 000	57 765
Neptune	16 300	6 575	22 875
Uranus	15 580	8 520	24 100

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From this calculation we see that the atmospheres of the outer planets are not only different with respect to volume but with respect to density. Therefore, the inconsistency of the changes in mean densities of the outer planets must be the result of properties of their atmospheres, in light of which the inconsistency of characteristics will be apparent.

On the basis of the obtained volumes of the planetary bodies and the planetary atmospheres their radii are calculated (Table 45).

TABLE 46

Bodies of Planets	Mass, 10^{27} g	Volume, 10^{27} cm ³	Mean Density, g/cm ³
Jupiter	1884	276.58	6.81
Saturn	562.8	96.20	5.85
Neptune	102.1	18.21	5.60
Uranus	86.2	15.50	5.55
Earth	5.97	1.08	5.51
Venus	4.86	0.93	5.19
Mars	0.66	0.16	4.09
Mercury	0.33	0.06	5.6

The observed differences in individual planets of the solar system do not exceed the limits of a *single model which is common to all the planets*. Studies made show that in order to understand the nature of the planets there is no need to assume different chemical compositions and different models for them. The task of the theory is not to separate the planets but, on the contrary, to search for their common base indicating the specific thing which results for each planet from its mass and distance from the Sun.

If we exclude the influence of the characteristics of the atmospheres on the characteristics of the planetary bodies then all the planets, with the exception of Mercury, will appear before us in the form of a gradual and orderly series (Table 46).

In light of that strict logic which appears in the characteristics of the bodies of the outer and inner planets, hypotheses which connect the densities of planets with their distance from the Sun seem unacceptable to us. /128

The general model for both the inner and outer planets which has been examined here is in some way related to models proposed by other authors. The Vil'dt model (1938) for Jupiter is known. According to this model Jupiter like the Earth, consists of a thick stratum of frozen matter (methane, ammonia, water) and a hydrogen-helium mantle. According to Jeffreys, Saturn consists of a core and a mantle with a radius of 32 thousand km and a mean density of 0.26.

The search for a general basis for understanding the nature of the planets has not developed in a rational way. Investigations have tended to differentiate the planets. The planets were divided into three groups on the basis of atmospheric compositions: I - planets consisting of metals and oxides; II - planets consisting of methane, ammonia and water and; III - planets consisting of hydrogen and helium (Brown). The major planets and the Sun were included in the gaseous bodies.

V.G. Fesenkov and A.G. Masevich [1951] proposed a hydrogen model for Jupiter.

The concept that planets were formed differently on the basis of composition played a large role in the modeling of the planets.

The most general concept concerning the evolution of matter is not related in any way to the formation of the stars, planets and comets which might not have evolved.

We must effect a change in the concepts of the nature of the planets.

SATELLITES OF THE PLANETS

Let us cite some known data on satellites whose total mass is /129 similar to that of the Moon. (Table 47).

TABLE 47

Satellites (and their Planets)	Diameter, km	Mass in Lunar Units	Mean Density, g/cm ³
Ganymede (Jupiter)	5000	2.09	2.35
Titan (Saturn)	4850	1.89	2.32
Triton (Neptune)	3770	1.88	4.9
Callisto (Jupiter)	4700	1.18	1.59
Moon (Earth)	3476	1.00	3.34
Io (Jupiter)	3470	0.95	3.19
Europa (Jupiter)	3100	0.64	3.03

For the satellites of the planets, just as for the planets themselves, inconsistency is characteristic of changes in the mean densities. We must assume that this inconsistency appears here also. The characteristics of the atmospheres must be included in the characteristics of the planetary satellites and as a result the mean characteristics obtained are just as we observe them.

To eliminate any influence from the atmospheres on the characteristics of the satellites, we must determine their volumes. The atmospheres of the satellites have distinct and different volumes, but their masses are quite insignificant, especially with respect to the total mass of the satellites. Without interfering with the accuracy of the calculations, we can assume the mass of the satellite to be the entire mass. We can then construct a graph: total mass of the satellite versus mass of the core. Two known points can be assumed as the base of the graph: one point is the /130 total mass of the Moon equal to 1 with a mass of the core equal to 4%; the other point is the total mass of Mars equal to 9 lunar units with a mass of the core equal to 14%. Such a graph is given in Figure 6.

We can see the dimensions of the satellite cores from this

graph. Since contraction occurs with the formation of cores in the satellites, it follows that the initial volumes of the satellites were larger than those of today. Table 48 gives the characteristics of cores and decrease in the total volumes of the satellites.

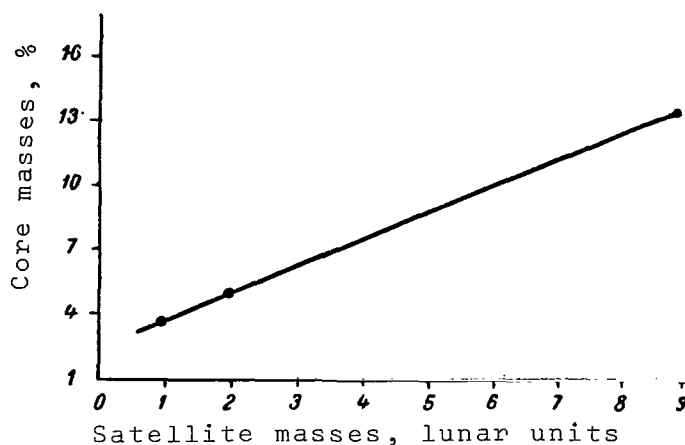


Fig. 6.

The volume of the modern Moon is estimated at $2.2 \cdot 10^{25} \text{ cm}^3$. If we assume that the Moon, during the time of its internal activity, has contracted by $0.07 \cdot 10^{25} \text{ cm}^3$ we must then assume its initial volume to be $2.27 \cdot 10^{25} \text{ cm}^3$. At the beginning the mean density of the Moon could not have been 3.34, but 3.23. With the formation of a core on the Moon the mean density increased insignificantly.

In other satellites of the planets their volume is as many times smaller or greater, compared with the initial volume of the Moon, as their mass is smaller or greater compared with the mass of the Moon. For example, if the mass of Ganymede were 2.09 times greater than the lunar mass, its volume would then have to increase 2.09 times in comparison with the initial lunar volume. It would have to be $4.74 \cdot 10^{25} \text{ cm}^3$. Since, however, in the development of Ganymede, the satellite contracted, its initial volume diminished by $0.21 \cdot 10^{25} \text{ cm}^3$. Therefore, the modern volume of Ganymede is $4.53 \cdot 10^{25} \text{ cm}^3$.

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Using the calculation for the volume of the modern Ganymede, the volumes of the other modern satellites of the planets were calculated. These calculations are given in Table 49.

The satellites of the planets, just as the planets themselves, are an orderly series of celestial bodies in which the core masses increase as total mass increases and the mean densities increase successively as the core masses increase.

On the basis of the known total volumes of the planetary satel-

lities and their volumes, it is possible to establish the volumes of their atmospheres. Calculations for the radii of the atmospheres are given in Table 50.

TABLE 48

Satellites	Core Size, %	Decrease in Volume, 10^{25} cm^3
Ganymede	5.3	0.21
Titan	5.1	0.18
Callisto	4.2	0.08
Moon	4.0	0.07
Io	3.95	0.065
Europe	3.4	0.037

TABLE 49

Body of Satellites	Mass, 10^{25} g	Volume, 10^{25} cm^3	Mean density, g/cm^3
Ganymede	15.34	4.53	3.38
Titan	13.87	4.12	3.36
Callisto	8.66	2.59	3.35
Moon	7.34	2.20	3.34
Io	6.97	2.09	3.33
Europa	4.69	1.41	3.32

The extent of the satellite atmospheres depends not only on the total mass of the satellite but on the external conditions. The satellites of Jupiter, Io and Europa, despite their small mass in comparison with that of the Moon have a gas mantle around them. Solar warming of the lunar surface increases the rate at which gases leave the lunar atmosphere. Under these conditions no stable atmosphere can be formed. It would seem that gravitation plays a role here also. /132

The existence of atmospheres has been known for some time for the satellites Titan and Triton. Recently it became known that Kalinyan (Pulkovo) had discovered atmospheres for Io, Europa, and Ganymede. Next comes discovery of the most extended atmosphere for satellites on Callisto.

The formation in the planetary satellites of atmospheres whose chemical composition is the same as for the planets relates the satellites to the planets. Both in planets and in their satellites there is internal activity and volcanic activity. As a result of

these common processes taking place on the planets, and with less intensity on the satellites, corresponding ratios of the primary planetary matter to the products of their decomposition are created. The distinction between the planets and the satellites may only be due to the ratio of primary matter to the decomposition products being great in the satellites and small in the planets. Planets and satellites are carriers of the properties of primary planetary matter and its decomposition products in their different ratios.

Triton, which with a total mass of 1.88 of the lunar mass, has a very high mean density (4.9) and is an exception to the orderly series of planetary satellites. A similar such phenomenon is also observed among the planets in the case of Mercury. That Mercury differs both from the outer and the inner planets can be explained by a collapse of this planet in the past. The "anomaly" of Triton can be explained much more easily by establishing a close relationship between the satellites and the planets. The internal activity indigenous to satellites and planets is a common cause for the destruction of some. In addition, in the case of Triton the possibility that it experienced a catastrophe before it became a satellite of Neptune can not be eliminated.

The 4.9 index for the mean density of Triton without allowing for contraction of the matter may be equal to 4.2 (Figure 3). We can see from the graph in Figure 4 that the size of Triton's core is established at 27%, this being $3.72 \cdot 10^{25}$ g. The chemically equivalent outer zone of the satellite, equal to $2.87 \cdot 10^{25}$ g (according to the ratio 1:1.2 from Table 14) and the intermediate zone, /133

TABLE 50

Satellites	Radii, km		
	Body	Atmosphere	Total
Ganymede	2215	285	2500
Titan	2150	275	2425
Callisto	1850	510	2350
Moon	1738	—	1738
Io	1709	26	1735
Europa	1520	30	1550

equal to $30.4 \cdot 10^{25}$ g, must correspond to this mass of the core. Thus, the total mass of Triton before the catastrophe could have been $37 \cdot 10^{25}$ g. With such a total mass, the core of the satellite would have comprised only 10% with a total volume of $10.3 \cdot 10^{25}$ cm³ and a radius of 2910 km for Triton. At the present time the radius of Triton is 1885 km. Its destruction occurred at a depth of 1025 km. In its present form, Triton remains at 37% of a former planet or satellite.

It is interesting to note that in Triton, as in Mercury, the destruction occurred at almost the same depths and with the same values of the core masses of 10-15%. These figures for the planets are probably critical for planets since they correspond to an increased intensity of internal activity.

With the decomposition of Mercury and Triton, stony meteorites reflecting the composition of matter of the outer zone, iron-stony meteorites reflecting the composition of matter close to the reaction zones and comets reflecting the composition of matter from the intermediate zones could be formed as fragments and could enter interplanetary sapce. Neither the planet Mercury not the satellite Triton sent iron meteorites into interplanetary space since their cores were not destroyed.

Satellites of planets, on the basis of their origin and properties, are *authentic planets* and it is of no importance whether they were formed as satellites or later lost their independence.

METEORITES

To know the nature of meteorites means to know their origin, /134
their chemical composition, the connection between the different
categories, the composition of the parent matter, the time of forma-
tion in interplanetary space and their future development.

Much information is available about meteorites. On the basis
of their composition meteorites are divided into three unequal (with
respect to numerical appearance) categories: stony, iron and iron-
stony. Within each category there is a great variation in individ-
ual meteorites on the basis of their composition.

Apropos of the origin of meteorites we noted above that they
are fragments of earlier existing planets. This means that the
composition of meteorites reflects the composition of the planetary
matter, i.e., each category of meteorite reflects the composition
of the planetary matter only at a certain depth of the planets.
Here precisely those meteorites which we did not consider earlier
because of their small numbers acquire special significance. Iron-
stony meteorites, carbonaceous chondrites and tektites, however
few in number they may be, reflect the composition of the deep-
seated strata of the decomposing planets.

Establishing the primary planetary matter from which the de-
composition products are formed is very important in perceiving
the nature of meteorites. Differentiated with respect to depth the
primary planetary matter is reflected in the composition of the
meteorites. We see that from the composition of the primary plane-
tary matter there results a precise ratio of large planetary frag-
ments with respect to their number and with respect to the connec-
tion between the categories. On the basis of this primary compo-
sition we can establish the time of the formation of the meteorites
and the time of their appearance in interplanetary space.

We can estimate the total number of meteorites and their ratio
in interplanetary space not on the basis of meteorites accidentally
falling to the Earth (in random ratios) but on the basis of the /135
masses of the cores and the mantles of the planets which have de-
composed. Earlier we showed that fragments of the satellite Triton
and the planet Mercury which had undergone collapse may have en-
tered interplanetary space. Of the $0.47 \cdot 10^{27}$ g of matter lost by
Mercury, $0.1 \cdot 10^{27}$ g were stony and iron-stony meteorites and
 $0.37 \cdot 10^{27}$ g were substances with the composition of comets. Of the

$0.232 \cdot 10^{27}$ g of matter lost by Triton, $0.03 \cdot 10^{27}$ g were stony meteorites and $0.202 \cdot 10^{27}$ g were comets. The finding of iron meteorites in interplanetary space indicates that in the solar system, evidently, there was another collapse of a third planet. This planet, in contrast to Triton and Mercury, completely collapsed with the decomposition of the iron core. There is some basis for assuming that this planet was Phaeton which was previously located between Mars and Jupiter. At the present time, there floats in this zone a cluster of fragments of varied magnitude. If the planet Phaeton was similar in mass to Triton and underwent a catastrophe at the same time as Triton then as a result of this event interplanetary space was replenished with iron meteorites with a total mass of $3.72 \cdot 10^{25}$ g, with stony and iron-stony meteorites with a total mass of $2.87 \cdot 10^{25}$ g and comets with a total mass of $30.4 \cdot 10^{25}$ g. These figures reflect the masses of the core and mantles of Phaeton prior to its collapse.

Thus, the total mass of matter entering interplanetary space with three large collapses in the solar system is: $0.15 \cdot 10^{27}$ g of stony meteorites, $0.04 \cdot 10^{27}$ g of iron meteorites and $0.87 \cdot 10^{27}$ g of comets.

The above estimation with respect to planetary fragments contained in interplanetary space does not differ fundamentally from observations. With respect to the total amount of fragments opinions are in agreement that their amount is approximately equal to the mass of a small planet. With respect to the large number of comets in comparison to meteorites probably that viewpoint is also not disputed.

For each planet the ratio of stony to iron meteorites must be on the order of 1:1.2. However, this ratio is not observed among the meteorites falling to the Earth. Among the meteorites found, stony meteorites occupy the first place on the basis of number, significantly fewer iron meteorites were found and very few iron-stony meteorites were found. We can understand such a ratio in light of the fact that stony meteorites fall to the Earth from three planets, iron meteorites from one planet and iron-stony meteorites are formed with the decomposition of a rather narrow reaction stratum at the boundary with the core. Tektite meteorites are also formed in insignificant amounts by weight, also because matter of this composition comprises a thin stratum of the mantle.

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It is not at all accidental that, among the meteorites, none have been found which might have a composition of the Earth's crust. The planetary crust could have been a film on the decomposed planets during their initial mass and growth because it is not reflected in the planetary fragments.

It is also not accidental that among meteorites the primary planetary matter has not been found, despite careful and prolonged searches. This is explained by the fact that it does not exist

in meteorites. We must look for it in comets. The composition of comets reflects the composition of the planetary matter of the intermediate zones. These zones are still very large in young planets. With the decomposition of the planets there appears an equivalent amount of the matter in the form of comets in interplanetary space. At the present time up to 40 million comets have been counted in the solar system. If this is actually so then we can say that this number of comets was formed from a protoplanetary cloud and as a result of the decomposition of planets, taking into account the decomposition and break-up of the comets themselves.

Meteorite-tektites occupy a special place among planetary fragments. Tektites are glassy bodies which are quite often encountered on the Earth's surface at several depths of the Earth's crust. These bodies have not been recognized at the present time either as meteorites or as terrestrial rocks. From our point of view *tektites are meteorites*; they reflect the composition of the planetary matter which is located at the depth of the third reaction zone of the Earth.

In the composition of the planet, tektites contain a significant amount of water and, perhaps, are similar to solutions. With the breaking-up of planets, tektite solutions collapse into small parts. The rapid evaporation of water in a vacuum furthers this break-up. The tektite matter is crystallized in flight and is formed into small balls or drops.

The meteorite origin of tektites agrees with meteorite characteristics. Thus, for example, in the composition of tektites there is an increased amount (on the order of 0.1%) of the microelement nickel whose content is characteristic of meteorites. In tektites there is almost no water and a very low germanium content. Water and germanium are volatile and freely evaporate with the formation of tektites. In the initial tektite composition water can be found in a state of a superheated vapor. The possibility of the degasification of tektites is quite obvious. /137

Zero intensity of magnetization is observed in tektites whereas volcanic glasses and glasses formed from sand rocks are very different in this respect. Tektites are found in tertiary clays. This can testify to their significant growth.

Conditions for the formation of matter of tektite composition on a developing planet and conditions for the formation of tektite bodies with a break-up in the planet are so specific that it seems that this can serve as a reliable guarantee not to ascribe any other origin to them. However, the many investigators of this problem do not agree that tektites are of meteorite origin.

According to the American astronomer G. Yuri tektites were formed from terrestrial rock during the collision of a comet with the Earth. We can agree with Yuri that the break-up of a comet on

the Earth may be accompanied by the melting of a siliceous rock with the formation of a glassy mass. However Yuri must agree that in this case the glassy rocks can be easily distinguished from tektites. Glassy rocks of instantaneous formation with random inclusions will have many signs which distinguish them from the tektite product that is formed under conditions of prolonged initial heating with the participation of deep-seated water.

According to the English mineralogist, Spencer, tektites could be formed with the fall of huge meteorites to the Earth. In fact, under these conditions the burning of siliceous rocks with the formation of glass is possible. However, this glass will resemble tektites even less than the glass of comet formation with respect to random inclusions and heating conditions of the mass.

The American astronomer, O'Keefe, assumes that tektites fall to the Earth with the eruption of lunar volcanoes. The volcanic variant of the "lunar" hypothesis concerning the origin of tektites has found many adherents since photographs of the Moon appeared. With respect to this hypothesis we must note that with the later study of the dark side of the Moon the conviction that there are fewer craters there than on the side facing the Earth can be disproved. In addition, the question arises as to whether the ring-shaped formations on the surface of the Moon are volcanic craters. Can the Moon with its modest total mass have volcanic activity at the same level as the Earth? If we must ascribe the origin of tektites to volcanic processes then would it not be better to ascribe the origin of tektites to the Earth's volcanic processes. This variant would be much more realistic. /138

The Australian, Baker, is the author of a hypothesis concerning the meteorite origin of tektites. According to this hypothesis, tektites were formed with the melting of the outer mantle of a decomposing planet. From our point of view, Baker's hypothesis, more than any other, approaches the true origin of tektites, especially if we introduce a correction into it: the tektite structures are formed not at the moment of the explosion of the planets but rather during the life of the planets as a result of a prolonged initial heating, and not as a result of the matter of the planetary mantle but rather as a result of the deep-seated matter of the mantle.

COMETS

With the formation of the solar system the condensation of the /139 dust matter of the protoplanetary cloud could occur not only with the formation of the major planets but with the formation of a large number of minor planets. Conditions for the condensation of matter in different zones of the protoplanetary cloud were so different that not all their material was condensed during the formation of the major planets, while the planets formed were far from identical in mass. The major planets are in a range from 317 earth masses for Jupiter to 0.1 earth mass for Mars.

The initial bodies of all magnitudes of the incipient solar system shared a common chemical composition. Bodies of all masses contained the same primary planetary matter and were carriers of common chemical properties. The difference between the major and minor bodies resulted only from the difference in their masses. In the interior of the major bodies conditions of temperature and pressure were created for the formation of internal activity; in the interior of the minor bodies such conditions were not created. If, however, dwarf planets in their orbital motion can occur under conditions of high external warming, then this can cause *their* activity, not internal but rather *external*. In this case the planetary matter on the surface of dwarf planets undergoes a chemical transformation only under the influence of high temperature. With respect to flow conditions these reactions are more similar to volcanic processes than to intrusive processes. Therefore, with the appearance of external planetary activity we must expect the same reaction products as with volcanic processes. The intensity and duration of the external activity of dwarf planets may depend on the time and proximity of their stay in the high-temperature zone. As it approaches the zone of high heating, the activity increases, /140 and as it departs, drops and finally ceases.

If the chemical processes penetrate from the surface of the dwarf planet to the interior of the body, they may acquire a progressive nature as a result of the fact that the heat of reaction remains in the reaction zone and will not be exchanged with the space surrounding the body. With such a nature of the process the binding stability of parts of the body is destroyed and it is broken up by the pressure of gases and vapors.

In connection with the above characteristics of a dwarf planet,

there arises the question of whether such planets exist in the solar system and what are the signs of their existence. We must give a positive answer to this question. Such planets have been observed but people, not suspecting that they have a very direct relation to planets, have called them comets.

Comets, in fact, in their orbital motion remote from the Sun do not exhibit activity and therefore are not detected. With approach to the Sun their external warming becomes sufficient for the appearance of external activity in them. A comet, not with the shadowed part but specifically with the lighted part of the surface facing the Sun, begins to eject gas and dust clouds, the movement of which is directed to the Sun. All these phenomena are far from random. Reactions between compounds of the primary planetary matter under the effect of high temperature are completely possible. Magna, water vapors and the gases of hydrogen, carbon dioxide, nitrogen, ammonia, etc. must be products of such a reaction. Reaction products produced on the surface of the planet are ejected because they have kinetic energy. The gas-dust cloud is ejected from the irradiated surface perpendicular to it. This direction coincides with the direction to the Sun. The cloud ejected in the direction to the Sun does not assume the shape of a very long tail, since the acceleration of the cloud particles is decreased by the pressure of light on the particles, moving in the opposite direction.

As soon as the comet in its movement crosses the perihelion, its surface which formerly faced the Sun becomes shadowed, but it preserves its activity for some time. In this state of the active surface of the comet the effect of the kinetic energy of the particles and the effect of the light pressure have the same direction--away from the Sun. The acceleration of the cloud particles /141 assumes such values that it expands for extraordinarily great distances in the shape of a tail. Calculations of the acceleration of particles for comet tails yield results which are too low in relation to observations only on the basis of the forces of the light pressure. In such calculations, in our opinion, we must consider the additional acceleration of the particles under the effect of their kinetic energy, which is produced during chemical processes on the surface of the comets.

The matter observed in the mantles and tails (water, ice, carbon dioxide, sodium and carbon radicals) comprises only certain products of such reactions which occur on the surface of comets in their state of external activity. Here, in fact, we should expect all those gaseous, vaporous and solid products which are formed during volcanic processes. In the conditions of outer space it is impossible to calculate the complete retention of products produced. Here, as in the conditions of planetary atmospheres, the primary volcanic products immediately undergo further chemical transformation.

In the comet Ikeya an isotope ratio of 1:70 was found for

C^{13}/C^{12} . This ratio is very near that observed on Earth (1:90). This may testify to the relationship between comets and planetary matter.

Each period of the activity of a comet is unavoidably accompanied by a loss in its mass. Despite the fact that the clouds ejected by comets are distributed in huge expanses, nevertheless the total discharge of comet matter is not large. This is explained by the fact that the density of the matter in comet mantles and tails is extraordinarily small. Such a density is very aptly characterized as a "visible nothing." The expenditure of matter by the comet with its activity in addition to everything else is limited by its surface. The surfaces of comets can not be significant if we bear in mind that their masses are insignificant. Thus, for example, the mass of Encke's comet with a cross section of 3 km and a mean density of 3.3 may be $3.4 \cdot 10^{17}$ g.

In light of what has been said concerning the nature of comets, it is interesting to examine several existing hypotheses in this field. Several authors assume that comets enter into the solar system from without and others see the sources of their formation in the solar system itself. It seems to us that the assumption of comet clusters on the periphery of the solar system can not be proof of their formation outside the boundaries of the solar system. On the contrary, at the periphery there are the most favorable conditions for the formation of bodies which are small in mass. In addition, in all cases where it is assumed that the solar system captures matter from without there is a counter argument: such capture is either improbable or not very likely. Why then do we make an exception with comets and assume that they are captured from without? /142

The views of Whipple and his followers who assume the composition of comets to be dust and gases cemented by ice do not seem absolutely acceptable to us. In spite of the naivete of this hypothesis it has been extended not only to comets but even to planets. Here the observed decomposition products of the planetary matter are taken as the initial planetary matter, whereas it is completely obvious that after ejection from a comet of certain portions of matter with a given ratio of component parts, it is the violent chemical process that is concealed rather than the physical process of the melting of ice.

It is also impossible to agree with the opinions of certain investigators who explain the flares of comets by explosions occurring in their collisions with various cosmic bodies. Here, in the first place, the probability of collisions between comets and other bodies clearly increases and, in the second place, no explanation is given as to why the flares are progressive and instantaneous.

In our opinion the degree and time of luminescence of the

comets are explained by the intensity of the chemical reactions on their surface. If the comet is not in a state of activity, then in general it can not shine. The possibility of its collision with other planets is probably no more than the possibility of collision with the Earth. A recently stated hypothesis of V. G. Fesenkov that the Tunguska meteorite is essentially a comet seems very probable to us. The flight of a comet in the Earth's atmosphere is equivalent to a flight in a zone of high heating. In contrast to the depleted planetary matter of meteorites, the primary planetary matter of comets is explosive. The fall of a meteorite to the Earth is accompanied by physical processes of warming up and the breaking down of the material. The fall of a comet to the Earth is an explosive process for which igniting activity and the activity of a shock wave are characteristic. Since this is a chemical process rather than a radiochemical process, there are no reasons for assuming increased radioactivity. /143

In conclusion, let us formulate the nature of comets. According to our concepts, bodies of the solar system are comets. The protoplanetary matter is the source of the *old* comets, while the intermediate zone of the decomposing planet is the source of the *new* comets. The matter of old and new comets with respect to elementary composition and chemical structure is the primary planetary matter. Comets just as planets are carriers of properties of the primary planetary matter. They are essentially *dwarf planets*. Dwarf planets in contrast to major planets possess external activity rather than internal activity, not always, however, but only when they fall into a zone of external warming. The degree and time of brightness of the comets are determined by the intensity of the chemical processes on their surface. The shape and extent of comet spheres are determined by the kinetic energy of the particles and by the light pressure on them. The break-up mechanism in comets consists of the penetration of chemical processes into the interior of the comet body. The vapors and gases found there rend the body of the comet into parts.

THE POSSIBILITY OF APPLYING THE PLANETARY MODEL TO THE SUN

The appearance of the Sun can be examined in close connection /144 with the formation of the planets. The Sun, just as the planets, was formed in a protoplanetary cloud with condensation of the primary planetary matter. In its formation stage the Sun could have been a gigantic planet, exceeding the mass of Jupiter by 1,000 times. The further development of the Sun was determined by the evolution of its matter. The elementary composition and chemical structure of its primary matter corresponds entirely to planetary matter. The specific nature of the Sun is determined, therefore, not by the composition and structure of its matter, but by its mass. The Sun, just as Jupiter, in its development increased 3.9 times more with respect to volume than with respect to mass.

Volume, 10^6 earth units.....1.29

Mass, 10^6 earth units.....0.33

Ratio of volume to mass.....3.9

Such a growth in the volume of the Sun in comparison with its mass can be explained by the formation of a very extended solar atmosphere. In order to obtain the same mean density for the body of the Sun as for Jupiter (i.e., 6.52), we must assume a nonconvective mass (body) of the Sun equal to $1.825 \cdot 10^{33}$ g with a volume of $0.28 \cdot 10^{33} \text{ cm}^3$. In this case the characteristics for the body and atmosphere of the Sun will be those shown in Table 51.

If, however, we bear in mind the fact that we do not know the ratio between the chemical reaction rates of Jupiter and the chemical and nuclear reaction rates of the Sun, we can not know where the error lies in such calculations. If the error is small, the core of the Sun must be approximately equal in mass to 51%.

We may assume that in the initial stage of the internal activity of the Sun only those deep-seated chemical processes could take place which under the new conditions of temperature and pressure /145 developed into nuclear processes. If, in planetary conditions, the decomposition of iron hydrides is accompanied by the formation of deep-seated water and hydrogen, then in solar conditions plasma corresponding in composition to metal hydrides of the iron family is decomposed with the extraction of helium. The total amount of

deep-seated water, chemically equivalent to the core of the body of the Sun, is perhaps $0.04 \cdot 10^{33}$ g. If this entire amount of deep-seated hydrogen underwent a nuclear process, then the helium being formed would partially or totally migrate to the solar atmosphere. However, in the solar atmosphere hydrogen is found in addition to helium. This must mean that not all the deep-seated water participated in the deep-seated nuclear process. Some part of it, unchanged, migrated into the atmosphere. The energy calculations of the influx and emission of heat by the Sun lead us to this conclusion.

TABLE 51

Sun	Mass, 10^{33} g	Volume, 10^{33} cm ³	Mean Density, g/cm ³	Radius, km
Body ...	1.825	0.28	6.52	406 000
Atmosphere	0.175	1.12	0.156	289 300
	2.00	1.4	1.43	695 300

The sizes of the influx of thermal energy within the body of the Sun are determined by the conversion of four hydrogen atoms with a total mass of $4 \cdot 1.00813$ g into a helium atom with a mass of 4.00386 g. In this process, energy equivalent to a "loss" of mass of 0.02866 g is extracted. It is equal to $E = 2.15 \cdot 10^{13} \times 0.02866 = 6 \cdot 10^{12}$ cal. If all the deep-seated hydrogen underwent nuclear conversion, the total release of energy would be $E = 1.5 \cdot 10^{12} \cdot 0.04 \cdot 10^{33} = 6 \cdot 10^{43}$ cal. The annual emission of heat by the Sun is estimated at $3 \cdot 10^{33}$ cal. If we take the time of the internal activity of the Sun as $5 \cdot 10^9$ years, then the total heat emission of the Sun is $1.5 \cdot 10^{43}$ cal. Comparing the values of the influx and emission of energy, let us note that the influx of energy is 4 times greater than its emission. We can easily eliminate this inconsistency by assuming that not all the deep-seated hydrogen undergoes nuclear conversion. Of the four deep-seated hydrogen atoms, one undergoes nuclear conversion and three do not participate in this process. This conclusion from the energy calculations does not contradict the nature of the thermonuclear process and agrees with the fact that free hydrogen appears in the solar atmosphere and continuously flows from it into outer space.

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The total amount of helium formed and deep-seated hydrogen liberated must be 2% of the Sun's mass. These lightest nuclei can migrate to the solar atmosphere with the greatest speed and can accumulate here. Actually, the increased concentrations of hydrogen and helium observed in the solar atmosphere can in no way be distributed throughout the entire volume of the Sun. This must be especially emphasized in view of the fact that a preconceived idea concerning a hydrogen Sun is current.

According to the calculation given in Table 51, the mass of the solar atmosphere is 8.7%, whereas the total mass of the volatile light elements is 3.5%. This means that the solar atmosphere is formed as a result of less volatile compounds and elements. The content of such elements can be greater than 5.2% if we bear in mind the expenditure of light elements from the solar atmosphere. This expenditure may be connected with the incomplete return of material of solar protuberances and the efflux of corpuscular rays.

The very fact that a solar atmosphere exists can testify to the differentiation of the solar matter. Individual atomic nuclei formed at great depths of the solar interior cover a path with a length of 500 thousand km and reach the upper boundary of the atmosphere. The fact that insignificant numbers of heavier nuclei, for example iron nuclei, have been found in the Sun's atmosphere can testify to the fact that the differentiation of matter on the Sun is also the result of processes reminiscent of volcanism. Flowing plasma currents carry away from the interior the heavier nuclei which, however, collapse and do not accumulate at the upper boundary of the solar atmosphere.

The average rate of the deep-seated nuclear processes on the Sun is determined by the annual formation of $2 \cdot 10^{21}$ g of helium. With the deviation from the average rate the deep-seated processes /147 can take on a progressive character and may be accompanied by phenomena similar to an earthquake and volcanism. Such processes in the interior of the Sun are reflected as a remote echo in the upper boundary of the solar atmosphere in the form of flares and splashes.

Important problems concerning the nature of the Sun such as the phenomena of its periodicity in activity can be explained by a change in the rate of the deep-seated processes. In connection with the flowing of deep-seated matter to great heights, the gravitational field is destroyed, thus possibly leading to a change in direction of the rotational axis (wandering poles) and the creation of new conditions for the deep-seated processes. In the interior of the Earth there are powerful forces but they are incomparably greater in the interior of the Sun and give rise to such changes in the body of the plasma star against the background of which the tectogenesis of the Earth's crust bears only a weak resemblance.

The observed periodicity in the internal activity of the Earth is closely connected with the change in movement of the reaction matter. The rotation of the Sun around its axis and around its center influences the internal activity by means of the mechanical mixing of the reaction matter.

CONCLUSION

The initial state of the solar system could be characterized /148 by the presence in it of a huge number of bodies, different in mass but entirely identical in elementary composition and chemical structure.

During the past billions of years significant qualitative and quantitative changes have occurred in the solar system. The qualitative changes were accompanied by the evolution of material which in the extreme case completes the cycle: cosmic gas and dust -- primary planetary matter, and depleted planetary matter -- cosmic gas and dust.

Evolution of the matter unavoidably entails the evolution of primary bodies of the solar system: planets, satellites of the planets and dwarf comet planets. These bodies constantly appear as carriers of the new ratios of the matter undergoing and not undergoing evolution. Properties of the bodies conform strictly to the degree of evolution of the matter of which they are made.

The evolution of the primary bodies of the solar system is accompanied by their breaking into fragments and dust. Interplanetary space is constantly being filled with secondary bodies, meteorites (stony, iron, iron-stony and tektite). The break-up of comets, the explosion of planets and the breaking-up and diffusion of meteorites continually increase the number of inhabitants of interplanetary space.

Probably it is correct to say that during the formation of the solar system there occurred the process of condensation of matter as a result of compounds with high chemical potential and the evolution of the solar system was accompanied by the process of breaking-up and diffusion of the depleted planetary matter.

Of the planets, Jupiter will decompose earlier than the others /149 if the Sun does not outstrip it in this respect. With its collapse, interplanetary space of the solar system will be filled with a huge amount of fragments and dust. By this means the gradual but unavoidable evolutionary process of conversion from one of the systems of the Universe (the solar system) to a nebula will occur.

At the nebula stage its matter will not cease its evolutionary

development. In these new conditions the dust particles from the depleted planetary matter will again become an arena for chemical, photochemical, radiochemical and radiation chemical processes. With a lapse in time, the dust particle matter will become primary planetary matter. Then the nebula will acquire new qualities; it will evolve into a protoplanetary cloud. A new variant of the solar system will be formed from it.

The eternal process of the origin and destruction of worlds and systems of the Universe probably occurs in such fashion.

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